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EARLY HISTORY AND MECHANICS OF THE CHICK BLASTODERM

A REVIEW

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EMBRYOLOGY, since attainment of its majority, has had two fundamental ontogenetic themes. The first has been the more nearly accurate description of the visible events of normal development down to the fate of the last cellular unit of the undifferentiated germ, with the purpose of exact localization of organ-forming germinal areas;—a theme formulated as such by Wilhelm His (1874) but already implicit in the fabric of embryological thinking bequeathed by Von Baer (cf. 1827, Schol. III. p. 157: '*Ein jedes Organ ist also ein modificierter Theil eines allgemeineren Organes, und in dieser Hinsicht kann man sagen, dass jedes Organ schon in den Fundamentalorganen enthalten ist, und zwar mit seinem ganzen Umfange*'). The second has been the investigation, in the tradition of Roux, of the properties of these areas: their initial innate capacities for growth and differentiation, their degree of independence, their transforming mutual relationships, and their regulability. In the chick, the first set of problems is now illuminated with much intrinsic light, while the second still depends in many ways on reflection from the analysis of amphibian development. This review will attempt to summarize the present state of these problems only for the primitive differentiation stage, which begins with the time of laying and is complete once the embryonic axis is morphologically patent.

I. THE GERMINAL AREAS

Today an outline of the events of normal development in the chick can do but little better than follow Von Baer's principles of primary, morphological, and histological compartition (*Sonderung*): i.e. the differentiation of the germ into layers and the closure of axial tubes therefrom; regional specialization of these primary tubes and layers into organs by differential growth; intimate specialization of their cellular components into differentiated tissues. Of recent years another principle has been recognized: the active migration of certain free cells or cell groups which very early dissociate themselves from the original layers: the neural crest and the *entodermale Wanderzellen*, or so-called primordial germ cells, are such early free components. In later stages, beyond the scope of the present discussion, many other cell types become migratory.

Although contributions to the description of the formation of the ovum and its development prior to laying are being added continually to the literature (Conrad and Scott, 1938; Olsen, 1942), the cleavage phase has never been studied from the point of view of germinal localization. The story must therefore begin with the time of laying, and continue through the first two days of incubation. In this period, primary compartition is completed, the morphological and histological compartitions only initiated. The major events are first, the achievement of a two-layered condition in the

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blastoderm, that is, division into an upper epiblast and a lower hypoblast; second, the formation of the primitive streak, through which agency the two layers are transformed to three definitive germ layers. These two overlapping processes constitute the first phase of primary compartition. Thirdly, there occurs the formation of the embryonic axis in front of the streak as the latter regresses.

There has been enough disagreement over terminology in the period of germ-layer formation to warrant a word of linguistic justification here. Hunt (1934) and others have used the term 'mesectoderm' in an inclusive sense, to signify the upper layer of the two-layered blastoderm, i.e., the cell layer destined to give rise to ectoderm and mesoderm, either before or during the process of separation. This usage, now somewhat questionably immortalized by a definition in Webster's Dictionary (2nd Ed. Unabridged), is common in classic cell-lineage literature: Wilson, speaking of the end of the spiral phase of cleavage in Nereis, says, "the embryo is 'two-layered' only in a conventional sense. The 'outer layer' is a mesectoblast in which the two components are completely separate." (1892, p. 393.)

Unfortunately, Platt (1894) also used the term in another context. The mesenchyme deriving from the amphibian neural crest she called mesectoderm, to indicate material histologically and topographically belonging to the mesodermal category, but deriving from the ectoderm after the main germ-layer separation is complete. Since this time, all students of the vertebrate neural crest have used the word in this exclusive sense. No case has been recorded where a real confusion of meaning has occurred. Korschelt and Heider, for example, in their text use 'mesentoblast' freely in the inclusive sense, and 'ectomesoderm' or 'entomesoderm' in the exclusive, without apparent difficulty.

It is far from the present purpose to decide on the inner logic of these uses, although the possibilities of argument are infinite and entertaining. Both meanings have functional as well as historical justification. In the specific case of the chick here under discussion, it has seemed to this reviewer best, especially in view of Hunt's work, to abandon the use of 'mesectoderm' for the venerable and non-committal 'epiblast' used by many English workers, against the possible day when 'mesentectoderm' might be in order.

The hypoblast

Concerning the first subdivision into two layers, our morphological knowledge is still not satisfactory, and experimental knowledge is practically non-existent. This is due of course to technical difficulties in the material. All students agree that, at the time of laying, the separation of the original cleavage disc into hypoblast and epiblast has progressed to a variable degree. Hays and Nicolaides (1934) and Peter (1938a) have recently demonstrated the extent of this variation.

Although this two-layered state was observed by the earliest students of germ-layers, the immediate origin of the cells composing the hypoblast has been a matter of lively controversy up to the present time. With the advent of serial sectioning, the germ wall and the loose cells in the subgerminal cavity were noted: these pictures left much room for speculation. In 1873 Balfour suggested that the free cells organized themselves into a coherent layer, below the epiblast. This view did not survive long, being displaced by the idea of an involution of superficial cells through the germ wall to form the lower layer (Götte, 1874; Duval, 1884). This concept of marginal involution, strongly denied by Kionka (1894), was revived by Patterson (1909) for the pigeon, and recently re-destroyed by Peter (1938b).

The deep layer of the germ wall has remained a possible source of cells found in the hypoblast of the central or pellucid area; another possible source has been the epiblast of that area itself: irregular cells have been observed apparently detaching from the lower surface of this layer. Recently Jacobson (1938a) has described a localized region of hypoblast invagination in the posterior germ wall, adjacent to the pellucid area: even, at advanced stages, an archenteron. This structure, as figured, unfortunately looks much like a revival of the *Sichelrinne* of Koller (1882), which all subsequent authors have pronounced an anomaly. The contemporary account of Peter (1938a) appears the best documented and most satisfactory one possible from a study of fixed, sectioned material. Peter describes the hypoblast as delaminating originally from the lower blastoderm surface, mainly in the posterior and lateral parts of the central (future pellucid) area. Wetzel (1929) has described the progress of this delamination into the germ wall in subsequent stages. According to this view the hypoblast is originally congruent with the epiblast.

Peter further describes a forward movement of the hypoblast, during the early period of incubation, so that the original central anterior incomplete region is moved near to the anterior germ wall, while a coherent, thickened, almost mesenchymatous area takes its place antero-lateral to the future embryonic axis (see Fig. 1). This area, the so-called *Entodermhof*, evidently comprises most of the anterior germinal crescent from

which the large 'primordial germ' cells are said to differentiate and to find their way individually into the bloodstream (for review, cf. Willier, 1939). Whatever the ultimate fate of these cells, they constitute one primitive contribution to the circulation. It is evident that they differ from other blood elements in being cut off before onset of the main invagination through the streak. If the descriptions of Wetzel and Peter are correct, the distinction between *Entodermhof* cells and those designated as anterior free mesoderm must be very slight: a difference in time of delamination rather than of essential history.

The above mentioned forward movement concerns both epiblast and hypoblast, as Peter shows by vital-stain marks. The same movement has been described by Wetzel (*op. cit.*), Gräper

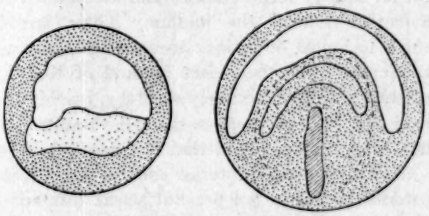

FIG. 1. RECONSTRUCTION OF HYPOBLAST ARRANGEMENT IN NEWLY LAID PRE-STREAK BLASTODERM (LEFT) AND EARLY STREAK (RIGHT).

Close stippling indicates coherent hypoblast layer; loose stippling, hypoblast incomplete (in first figure); in unstippled areas, hypoblast is represented by scattered cells only. In the right hand figure, *Entodermhof* and streak are outlined, and boundary of embryonic shield is indicated by a broken line.

(Adapted from Peter 1938a, Figs. 9a, 11a).

(1929), and Pasteels (1937); it is part of the complex deformation leading to the appearance of the primitive streak. As the latter takes shape, the hypoblast becomes fused to it in certain regions (as Remak was able to show by dissection in 1851); only after the regression of Hensen's node does the hypoblast again become a fully distinct layer, or entoderm.

It is now time to ask what exactly is meant by hypoblast. This membrane has been identified with entoderm since the introduction of the germ-layer terminology. However, even after the recognition of the role of the primitive streak, many authors believed this lower layer to be a source of mesoderm or chorda. Götte (1874) and Disse (1878) thought of the whole streak as originating in the hypoblast; Balfour and Deighton (1882) more conservatively found that only the more peripheral parts of the mesoderm arose thus. In recent times, many authors have decided, from study of sections also, that it is impossible that mesoderm originate from the lower layer; it must be noted, however, that no critical evidence from modern marking methods has as yet been brought forward to rule out absolutely a cellular contribution from hypoblast to mesoderm, especially in peripheral regions.

A cellular contribution in the reverse direction, i.e. streak to hypoblast, suggested on morphological grounds by various authors (cf. Holmdahl, 1933) has been observed by Hunt (1937b) in the case of transverse sections of the primitive streak marked with vital stain and allowed to continue invagination *in vitro*. Spratt (in his demonstration at the 1942 meetings of the American Association of Anatomists; also by personal communication) has confirmed these results by tracing carbon particles originally placed on the epiblast into both mesoderm and hypoblast cells, in this case on whole blastoderms grown *in vitro*. The full extent of such a contribution to the hypoblast can at present be only a matter of speculation. As will be seen in a later section, the developmental pattern of the entoderm has thus far not been dissociated from that of the overlying mesoderm. One possible although radical explanation is that the cells of the definitive entoderm are mainly those contributed to the hypoblast by the primitive streak.

Mesoderm formation

These remarks on the later history of the hypoblast have led us a little ahead of the chronological story. Immediately following the delamination of the hypoblast, the primitive streak appears as an irregular thickening in the posterior part of the pellucid area; within a few hours it elongates, taking on its definitive form as a median groove flanked by two thickened ridges, and bounded anteriorly by Hensen's node with the primitive pit at its centre.

The primitive streak, although undoubtedly seen by observers from Malpighi onward, and recognized as a distinct structure since the monograph of Dursy (1866), remains today a morphogenetic enigma. Kölliker (1879) established the streak as a source of mesoderm; gradually it became accepted as the only source of mesoderm (cf. Nowack, 1902); there is no specific reason at present to question this view. Kölliker and Balfour envisioned mesoderm as arising from the streak by proliferation of the epiblast cells in that

location; according to this view the original site of mesoderm would be in a narrow median strip of the original epiblast (Fig. 2, A). Even earlier, however, others had considered the possibility of movement of material in the blastoderm. The concrescence theory, advanced by His in interpretation of the formation of the embryonic axis in the teleost and only tentatively applied by him to the chick, has been one of the most fruitful errors in the history of embryology. His (1877) clearly recognized that the formation of a thickened primitive streak might be accounted for in two ways: either by proliferation *in situ*, or by the moving in of lateral areas. The form of the groove suggested to him that the latter was the case. He did not envisage mobility in the individual cells of the epiblast or hypoblast, although admitting a possibility of wandering of mesodermal elements: '*Die Möglichkeit, dass Wanderung dabei* (in the formation of the heart anlage in the primitive streak stage) *in Spiele sind, lässt sich nicht von vornherein abweisen; denn, wenn für die Zellen der beiden Grenzblätter eine aktive Lokomotion wegen der festen Zusammenfügung höchst unwahrscheinlich ist, so besteht kein ähnliches Bedenken für die locker verbundenen und theilweis vollig freiliegenden Zellen der intermediären Schicht*' (*op. cit.*, p. 148).

Following the original intimation of His, and the descriptions of Götte (1874), the idea of concrescence was elaborated into a principle of primitive streak formation by Rauber (1876, 1883) and illustrated by diagrams bearing only accidental resemblance to any blastoderm living or dead. The ultimate view of Rauber seems to have been that the primitive streak itself arose from material originally in a posterior sub-marginal position: i.e. from the 'lunula' or '*Sichel*' (Fig. 2, B). In 1876 he indicated a belief that not all of this crescentic area moves toward the median line to invaginate, but only the central part; the more lateral portions he supposed to be the site of mesoderm formation in place. The posterior margin of the blastoderm was considered to be the original site of invagination of the entoderm as well. Data for the 'Sichel' were furnished by Koller (1879, 1882) whose carefully drawn figures have aroused only skepticism among subsequent workers, who have been unable to find so definite a structure in the posterior germ wall, and especially unable to find an invaginating groove therein.

Whitman (1878, 1883) adopted enthusiastically the idea of concrescence, and it was in his laboratory that Patterson (1909) sought supporting evidence in the pigeon egg by injury experiments which did not adequately take into account the difficulties and drawbacks of such a method.

By the 1890's, the ontogenetic implications of the concrescence principle, originated as a comparison and developed in the interests of phylogenetic consistency, were appreciated and used as an experimental target. Assheton (1896), then Peebles (1898, 1904) and Kopsch (1898, 1902) demolished the target to the satisfaction of most embryologists. Sable hair markers (Assheton) at the posterior margin of the round blastoderm remained in position as the streak developed; on the other hand, markers placed in the centre of the blastoderm and on the posterior radius, came to lie first along the streak, then within or behind the embryo. Miss Peebles (1898) similarly marked regions in or near an already formed streak and ascertained no movement toward the midline. There are of course technical objections to such hair-marking experiments; but the defect method of Kopsch, greatly improved in accuracy since the time of Warynski and Fol (1883), gave the same results. In 1904 Miss Peebles found that hot needle injuries at the anterior and posterior ends of the median posterior radius do not prevent streak formation, but come to lie anterior and posterior to a partial embryo. Injury of the whole radius does of course prevent formation of a streak and of an embryo. This evidence, then, all pointed to the origin *in situ* of the primitive streak.

In the early 1920's, in Würzburg, inspired alike by the dynamic imagination of Braus and by the successful vital-staining method that Vogt had now evolved, Wetzel undertook to redescribe the events leading to the formation of the primitive streak and the embryo. By vital stain marks he detected striking shifts in superficial material of the pellucid area, before and during the formation of the streak: lateral from the anterior midline toward both sides, posterior and median in the posterolateral areas. As the streak proper appears, lateral material converges toward it all along its length. These movements, detectable only by marking and watching living blastoderms, are of the nature of deformations of whole areas of a continuous epithelium: as one cell group moves, another flows or squeezes in to take its place. In the midline, converging cells pile up, lose continuity, and invaginate to form the visible streak. Gräper (1926, 1929) has confirmed the main aspects of these observations by cinematography; thus certain features of the concrescence principle are

given validity, after many years. The maps of Wetzel (1929), in conjunction with his careful study of and reconstructions from serial sections, constitute the greatest advance in our understanding of the primitive streak since the general topography of the early blastoderm was set forth by Dursy and Kölliker (Fig. 2, C).

Wetzel remains the artist-morphologist rather than the expositor; in his 1929 paper the experimental information far outruns the interpretation, so that we must set down his contribution as basic rather than definitive. Pasteels (1935, 1936, 1937), has made a few pertinent corrections of the Wetzel scheme, and has succeeded in substituting a more exactly localized map, bringing light into

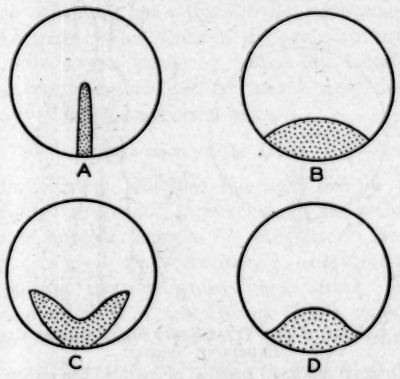

FIG. 2. DIAGRAMMATIC REPRESENTATION OF THE ORIGINAL SITE OF MATERIAL COMPOSING THE PRIMITIVE STREAK.

According to a) Kölliker-Balfour; b) Rauber; c) Wetzel; d) Pasteels.

several obscure places (Fig. 2, D). His most striking advances are in showing that the first configuration movements in the blastoderm concern both epiblast and hypoblast, whereas the lateromedian movements toward the streak occur in the epiblast alone; and that superficial regions on the border of the streak can be stained electively so that marks may be traced into definite regions of the mesoderm. Thus lateral plate, somites, and chorda are represented by definite superficial regions which invaginate at a definite time and place. That something like this must be true was obvious from Wetzel's figures and from general considerations; the demonstration of Pasteels is clear and logical, and his map (Fig. 3) is by far the most satisfactory one to date.

As every worker with vital stains on the chick, and especially Wetzel, has recognized, there are limits to the trust one may put in a localized mark. Every mark transferred to the blastoderm through the vitelline membrane, tends to spread initially. After that, it retains its shape for a time subject to the motions and distortions of the blastoderm. It is true that certain regions or cell types tend to store the dye, while in others it disappears rapidly. Eventually all marks disappear, undoubtedly through reduction, since signs of diffusion, in the pellucid area at least, are absent. None the less, the experience of careful observers such as Wetzel, Pasteels, and Hunt shows the vital stain mark to be consistent in its behaviour over a limited period; the view of Jacobson (1938b) that Nile Blue

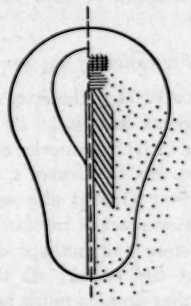

FIG. 3. DISPOSITION OF PROSPECTIVE AREAS IN THE DEFINITIVE PRIMITIVE STREAK STAGE, ACCORDING TO PASTEELS.

Left side shows ectoderm with medullary region outlined; right, invaginated material. Cross-hatchings, head mesoderm; horizontal lines, chorda; oblique lines, somites; stippled area, lateral plate-blood. (Pasteels, 1937, Fig. 19d redrawn).

sulfate must necessarily, because of its association with lipoids, disappear by diffusing from the cells as they lie in the primitive streak, is contradicted by figured experiments of other workers and is so far supported by no exact evidence.

Kopsch (1926, 1934) has countered Wetzel with a modified map reiterating his earlier views on the origin *in situ* of the streak and embryo; however none of his injury experiments is incapable of being fitted into the Wetzel-Pasteels scheme, as is shown by the extensive experiments of Twiesselmann (1938). These demonstrate that, although it is possible by delicate electrolytic injury to produce, in the unincubated or pre-streak blastoderm, a scar that will come to lie in a definitely localized part of the embryo, such damage always has a complex effect, which may proceed even to the extent of producing duplication or triplication of the

embryonic axis. This emphasizes that for marking purposes, the cautery or electrolytic defect is an unreliable tool.

Even the improvements wrought by Pasteels, in tracing germinal areas through the streak, leave us with an incomplete idea of the events taking place. The areas destined to become heart, nephros, and limbs have not been adequately located, nor has the extraembryonic mesoderm. There is no attempt to show the neural crest or placode sites in the ectoderm, and of course no hypoblast areas are traced. The invagination process is only approximately indicated; the fate of the early non-streak mesoderm is not specified, while the morphogenesis of the streak itself continues to be a topic of both investigation and speculation.

Formation of the streak

According to Wetzel, the streak, after its first appearance, grows anteriorly by pushing other material ahead of it: the anterior end of the streak always corresponds to Hensen's node. Pasteels (1937) and Peter (1938a) also agree that there is a forward movement of median material of the blastoderm before and perhaps during the first appearance of the streak; all the experiments figured show that an area much broader than the streak itself is concerned. It is not necessary to think that the growth of the streak causes this general movement. The Pasteels map implies a view similar to that of Nowack (1902), namely, that the early streak grows anteriorly by inclusion of new material in the invaginating line as well as by stretching of the whole blastoderm. The latest evidence to this effect is that of Spratt (1942a), which shows that the streak in explanted blastoderms grows forward by progressive inclusion of anterior areas, rather than by displacing them. As he has put it (*op. cit.*, p. 95): "Hensen's Node thus may be regarded as a structure formed by the union of the streak with chorda material which at first lies anterior to it." This anterior prolongation actually accounts for but a fraction of the total increase in streak length. An intussusceptive growth of the streak parallels that of the whole blastoderm, anteriorly as well as into the posterior bulge.

The figured experiments of Pasteels show the major directions of emigration of mesoderm from the streak, as it first elongates, to be lateral and posterior, so that a median linear area will come to be disposed in a U-shape (see Fig. 4, B). It would be of great interest to know if this pattern continues to repeat itself in later stages. We know from Wetzel's figures that very early in its course of elongation, the streak may be divided into two regions: an anterior, somewhat loosely constructed portion, and a posterior compact one; and that these regions are traceable until the streak loses its identity. The anterior portion is designated as the '*Ebene*'; a mark in the posterior region of this area comes to lie in the endbud: thus the *Ebene* contains the material for practically the whole embryonic axis. In early stages it is clear that mesoderm emigrates more rapidly from this portion of the streak than from elsewhere;

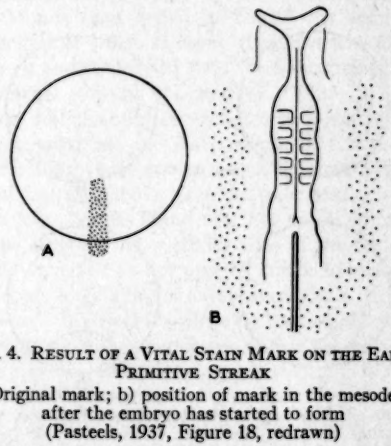

FIG. 4. RESULT OF A VITAL STAIN MARK ON THE EARLY PRIMITIVE STREAK
a) Original mark; b) position of mark in the mesoderm after the embryo has started to form
(Pasteels, 1937, Figure 18, redrawn)

the relationships in the definitive streak and later have not been studied.

In regard to the invagination process itself, the histochemical observations of Jacobson (1938b), showing the loss of glycogen and lipoid material in the invaginating cells of the streak, are extremely valuable, and indicate a whole field where we badly need information. In particular, we need histochemical methods which do not destroy architectural relations. Abercrombie (1937), Waddington and Taylor (1937), and Jacobson have all emphasized the importance of what may be called the de-epithelialization process in the streak. As the epiblast moves into the streak, it is a coherent epithelium; as mesoderm, it loses its coherence. This capacity of alteration in surface relationships is a common property of epithelia, and in this case is undoubtedly bound up with the other metabolic changes occurring at the time of invagination.

As for the role of mitosis in mesoderm formation and in other activities of the streak, Pasteels pronounces definitely against the existence of any differential between streak and non-streak epiblast in mitotic rate (1937). This statement is based on mitotic counts in one blastoderm. A more extensive study of mitotic indices by Derrick (1937) is available, indicating that there is in general a higher mitotic rate in the epiblast just peripheral to the streak than elsewhere; however, the counts in at least one case (# 4-62) show a differential in favour of the streak region. It is undisputed that mitosis does occur in the streak, and thus plays a certain role in the history of invaginating areas; it is not known if any sort of regular pattern is present. Miss Derrick's counts show uniformly less mitosis in the node than in other parts. This phase of the primitive streak problem awaits study by means less laborious than counts in serial section, means permitting a survey of larger numbers of cases.

Regression of the streak

Immediately following the formation of the definitive streak and Hensen's node, the embryo proper appears, anterior to the latter. Dursy (1866) is given credit for having made clear the distinction between embryo and streak. The account of Prévost and Dumas (1827) contains passages seeming to indicate that these writers were aware of the topographical relations of the two structures, had they not explicitly confused them a page or two farther on.

That the embryo increases in length and that the streak shortens has been clear to all observers who have troubled themselves with the matter; but how this occurs, what material goes into the embryo, and what happens to the streak in the process are not questions to be answered by study of serial sections. The experiments of Miss Peebles (1898, 1904) had the express purpose of discovering the relation of the streak material to the embryo. She made sure that at least a part of the head arose anterior to the node: a transverse cut anterior to the streak eliminated the forebrain; an injury to the whole streak except the anterior end permitted the head and a few somites to form; the anterior end itself was judged to correspond to the level of the first somite and heart. Injury to the middle third of the streak permitted development of the embryo to the tenth or twelfth somite level; an injury to the posterior third of the streak damaged the caudal region of the embryo. These results supported in a general way the idea of point-for-point correspondence of the streak and embryonic axis to which Kopsch had been led by similar experiments. Other aspects of the varied injuries performed by Miss Peebles, showing the prevention of development anterior and posterior to the node by blocks, and the general sensitivity of the node region, were ignored in this interpretation.

Continuing his analysis, Wetzel (1929) has presented a careful 'formal' history of the regressing streak, the outlines of which are indicated in Fig. 5, adapted from his series of graphic reconstructions. In order to emphasize the relations in the streak, the junction between the *Ebene* and the posterior thickened (future extraembryonic) portion is taken as a constant point,—there being of

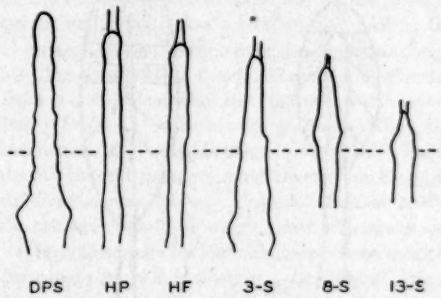

FIG. 5. OUTLINES OF PRIMITIVE STREAK IN SUCCESSIVE STAGES OF REGRESSION
Interrupted line shows approximate junction between *Ebene* and posterior streak
(Traced from graphic reconstructions of Wetzel, 1929)

course no really constant point on the continually growing and shifting blastoderm. These figures show clearly that the extent of streak regression by no means parallels the growth of the embryo ahead of it; and that the real shortening of the streak does not begin until after the head-process and head-fold are well established. Both halves seem equally affected by the retraction.

The first vital stain experiments of Wetzel showed that the material in and adjacent to the definitive primitive streak is far from being arranged on a simple level-for-level plan with reference to the future embryo. Ectodermal marks lateral to Hensen's node kept a corresponding antero-posterior arrangement after the embryo was formed; marks made in the midline showed extraordinary posterior stretching. Projected back on the primitive streak blastoderm,

each level of the embryonic cross-section appears sharply condensed in the midline, as Fig. 6 shows, the dorsal axis focussed in the primitive pit. As the embryonic region lengthens, the whole streak level is shifted relatively posteriorly and eventually the streak itself shortens, as has been seen. The lengthening of the embryo thus is accomplished in part by the elongation of the node region. When the streak has shrunk to perhaps half its original length, the medullary plate, rising progressively in antero-posterior direction, has so to speak overtaken the node, and the sinus rhomboidalis is formed.

By extirpation of Hensen's node, Wetzel could demonstrate a block to development posteriorly.

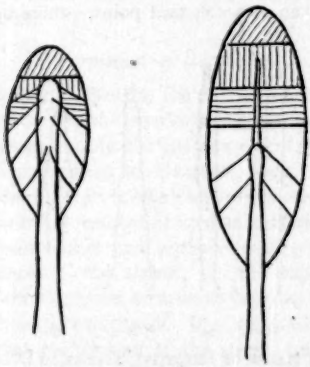

FIG. 6. PROSPECTIVE AREAS OF THE MEDULLARY PLATE IN DEFINITIVE PRIMITIVE STREAK AND HEAD-PROCESS STAGES.

Oblique shading, forebrain; vertical, midbrain; horizontal, hindbrain; levels corresponding to somites 1, 6, 12 indicated by paired lines in unshaded region. (Modified from Wetzel, 1929, Figs. 119, 129).

His first suggestion (1925), that the node was comparable to the amphibian organizer, was withdrawn as his analysis became more nearly exact. The node, he concludes, is in its action more like the amphibian tailbud: it is a source of material for chorda and the neural floor, in all the axis but the forebrain region; laterally adjacent parts supply the somite mesoderm and corresponding medullary plate. Hence the result of removal of the node is radical, especially since it is inevitably accompanied by further widening of the hole in the blastoderm. This general view, and some details of the map, were verified by Wetzel in a series of transection experiments (1936), where delicate cuts with a glass needle were made at various critical regions in the otherwise undisturbed blastoderm. The strong posterior growth tendency of the node, and the primitive location of material for somites, chorda, and medullary plate, are clearly shown in this way. Less clear are antero-posterior localization of paraxial structures and the various relations around the sinus rhomboidalis. Wolff (1936) has offered a diagram of relations of prospective mesodermal areas in the regressing streak itself, not based on precise experiments, but on general results of

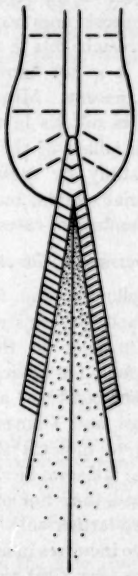

FIG. 7. PROSPECTIVE MESODERMAL REGIONS IN THE REGRESSING STREAK

Oblique lines indicate uninvaginated somite material; interrupted lines, invaginated somite material; stippled area, uninvaginated lateral plate. (Modified from Wolff, 1936, Fig. 101b)

destruction or inactivation of localized regions of the germ by x-rays (see Fig. 7). Such an arrangement is a possibility, although the continued posterior divergence of the limiting lines is inadmissable; as a first approximation at analysis of the mature streak, it offers concrete suggestions for future work. It is possible that Pasteels has some such arrangement in mind when he describes the regressing node as *cleaving* the somite material in its passage (1937, p. 452)—an otherwise uninterpretable expression. Until we know the course, quantity, and limits of invagination in this period,

the history of the formation of the posterior head and trunk will involve a great deal of speculation.

Isolation of different levels of the definitive or post-definitive streak, either *in situ* (Wetzel, 1936) or *in vitro* (Waddington, 1932, 1935; Rudnick, 1938a, c) not only confirms the map localizations, but indicates certain localized growth tendencies. In the node we have a portion destined to elongate tremendously in the midline, progressively less in lateral regions. This elongation occurs independently of posterior levels, regions normally invaded by the node. The remainder of the embryo-forming half of the streak —the *Ebene*— will undergo a corresponding movement even in isolation. This includes condensation and an energetic lateral movement, which together spread the anterior edge into a V or U shape if the whole posterior blastoderm is explanted, but which produce a long contorted cord joining lateral coelomic vesicles, in case the *Ebene* level only is explanted. The posterior half of the streak undergoes no such motions in isolation; *in vitro* the streak tends to disappear in a mass of hemopoietic tissue (Murray, 1932; Rudnick, 1938a). Although this posterior half quite certainly forms some lateral embryonic structures, it is evidently brought into position by no active motions of its own. Fig. 8 is an attempt to summarize this morphogenetic information.

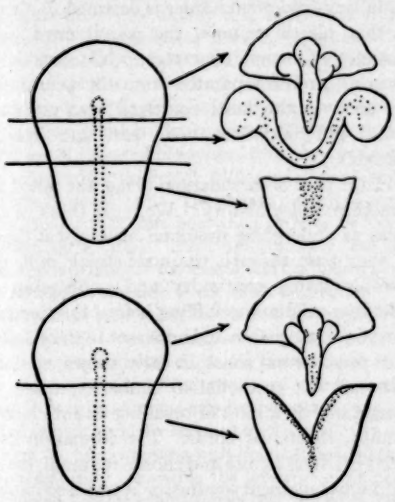

FIG. 8. DIAGRAM OF GROSS FORM CHANGES WHEN TRANSVERSE STRIPS OF THE PRIMITIVE STREAK BLASTODERM ARE CULTURED SEPARATELY.

Forebrain and bilateral heart vesicles form from the region around the node, while the anterior streak (chorda) elongates strikingly. The next level thins medially, and vesiculates laterally. If this level remains attached to the posterior blastoderm, a V-shaped medullary thickening forms, representing the posterolateral medullary plate.

(From results of Waddington, Rudnick)

Thus although the regression of the streak must in part be ascribed to a cessation of invagination, so that the material going out as mesoderm is no longer balanced by material flowing in from the epiblast, we must also take into account a certain directed condensation and shifting, culminating in the formation of the massive endbud.

Secondary body development: trunk and tail

Holmdahl, in a valuable series of papers (1925 to 1939) has emphasized the fact that only a part of the embryonic axis is laid down by the primary primitive streak-germ layer route. After the closure of the neural tube over the sinus rhomboidalis, the remainder of the dorsal axis forms directly from a solid blastema, the endbud, which eventually forms the core of the tailbud. That the mechanics and organization of such differing developmental patterns must themselves be quite different seems obvious. Unfortunately, no analysis has been made of where these differences lie.

The errors made by Holmdahl have been quickly corrected by other workers. In general, these errors were of two kinds: an inaccurate localization of the boundary between the parts of the axis formed by the two methods respectively; and an inadequate appreciation of the relations existing between the dorsal axis and prospective ventrolateral trunk regions on the still flat blastoderm. The variability in subsequent position of marks made "just anterior to the endbud" emphasizes the extreme condensation of the trunk axis in the early endbud stage. The extirpation experiments figured by Gräper (1933) and Frölich (1936) show satisfactorily that in endbud stages the hind limbs lie in the germ layers lateral to the endbud, while this structure itself forms only tail. Wolff (1936) offers indications for the localization of the hind limbs posterior to the sinus in pre-endbud stages; these results of x-ray injury are not as clear-cut as those of surgical removal would be, and are not confirmed by the results of Zwilling (1942), nor do they coincide in detail with recent information from coelomic transplantation (Rudnick, 1944). It is evident that the rhomboidal sinus forms the dorsal trunk axis; Holmdahl thinks of the sinus as a transitional zone be-

tween primary and secondary types of development. The ventral and coelomic portions of the posterior trunk at this stage seem already to lie outside the axis proper.

Empirically, formation of the embryo may be understood as occurring in three distinct steps. In the first of these, the head-forming phase, head structures are clearly laid out both laterally and anteriorly as germ layers before morphogenesis begins (e.g. in the head-process stage). Only the most dorsal structures are concentrated in the node and anterior streak; the regression of these regions brings about definitive spatial relations, followed at a brief interval by actual morphogenesis of medullary tube, chorda, somites, etc. The relatively large size of the various germinal areas of the head in the early blastoderm has facilitated localization and other experiments.

The next step is trunk formation. As the node approaches its own posterior limit, the early sinus rhomboidalis contains within its short confines all the axial material for the trunk and tail. The trunk, then, is in its pre-differentiation period laid out on a much smaller scale than that of the head at a corresponding period; hence the lack of experimental knowledge of the trunk, and the confusion as to its limits. It has not been possible to trace differential movements of paraxial layers; but it is probable that the mechanical differences between head and trunk formation lie only in differences of scale and morphogenetic time sequence. The dorsal axis, as has been indicated, forms in a pattern transitional between primary and secondary patterns.

Thirdly, as to the tail itself, differentiation from a blastema means that the cellular material representing this structure, at head-process stages for example, is practically infinitesimal. In the sinus rhomboidalis, tail blastema is probably represented in the posterior median border, although injury experiments at this stage have given contradictory results (cf. Fröhlich, Zwilling, *op. cit.*).

In the foregoing discussion the developing blastoderm has been envisioned as a sort of jigsaw puzzle with fluid properties, in which definite areas are followed through deformations and size changes, until they finally take shape as embryonic organs. This is not difficult in the case of ectodermal structures: the superficial prospective medullary material can be visualized as first lying somewhere near the centre of the blastoderm, and being modelled, as the streak forms and grows, into the long oval shape (*Scheibe* of Wetzel) shown in the maps of the head-process blastoderm. Visible thickening of the epithelium to a columnar type accompanies these surface alterations. Once the definitive form is attained, the peripheral boundary of the area will rise as the medullary folds, and close over to form the primary neural tube, in the manner known to every college student of embryology.

The outlines of the original potential medullary area cannot be thought of as sharply defined. The medullary-epidermal border is destined to give rise to that plastic enigma, the neural crest, which partakes of neural character; while outside this boundary, quite separated from the neural plate, are areas in the head epidermis also capable of neural differentiation: nose, ear, and branchial placodes.

In the case of mesodermal areas, the maps show a more complex history. We must think of these areas as undergoing profound histological changes as they pass through the node-streak mill, quite possibly losing continuity and undergoing considerable cellular reshuffling before they emigrate to a position beneath and adherent to the ectoderm. This mesodermal sheet, in early stages continuous although not epithelial in character, takes form apparently by a kind of breaking up into localized clumps, sheets, or cords. The formation of the clefts between somite and chorda material, between individual adjacent somites, or between somatic and splanchnic layers must be traceable to differential mutual adherence of localized cell groups. A definite pattern of cell multiplication must reinforce these processes.

As for entodermal structures, we still lack direct information. The implications of isolation and transplantation experiments do not encourage the view that entodermal areas are represented point for point in the early hypoblast.

II. PROPERTIES AND DYNAMIC RELATIONS OF THE GERMINAL AREAS

Localization studies define germinal areas, but tell nothing of their intrinsic properties. These must be studied by interventions more radical than marking experiments. In general, such properties may be grouped under two rubrics. The first includes the immediate cellular physiology of the areas, especially considered as causing or conditioning germinal movements. The second comprises genetic properties of the areas, especially their capacity to differentiate in altered surround-

ings either into structures which they would have formed in the course of normal development (*bedeutungsgemäss*) or in other directions (*bedeutungsfremd*). The dependence or independence of such differentiation and the analysis of causal factors are of course included, these being, in other words, the set of problems frequently referred to as 'determination'.

Differentiation may refer to events on almost any scale, from changes in individual cells or cell parts to mass transformations of whole embryonic regions. These different events usually can, in the case of any one structure, be dissociated experimentally, and thus may be attributed to dissociable sets of causal factors. Strictly, if we are to speak of 'determination' as an antecedent invisible differentiation, we must specify exactly what event is 'determined.' The current imprecise use of the word has robbed it of any discriminatory value, while loading it with connotations which we prefer to avoid here. The precise concept of segregation (Lillie, 1929) has been used to refer to 'determination' on a cellular level; unfortunately, the test prescribed is in practice too severe, and has almost never been fulfilled in the case of the chick blastoderm.

The point of view taken here is that embryonic cells previous to differentiation may exhibit varying degrees of autonomy when isolated, ranging from almost complete self-sufficiency (blastomeres of some marine forms) to complete dependence (within our experience) on local factors normally supplied by the germ. In any one form, by experimenting with isolation methods and by systematically comparing the behavior of different areas, some general evaluation of the degree of independence of various regions at successive stages may be reached. That these regions in fact possess a measurable degree of autonomy is only a preliminary description: there is no reason to believe that areas of similar independence or dependence have any of the real directive mechanisms in common. These mechanisms may be intracellular or extracellular, may involve few or many cells. In general, descriptions should furnish data that may bear on specific differentiation machinery, rather than try to fit themselves into a general vacuous concept such as 'determination.'

The autonomy of any one area increases with time during early development. The role of susceptibility to inducing stimuli ('competence': Waddington) in this increasing autonomy is still a matter of study, even in the perennially studied case of the medullary plate, where there are reasons to question the view that induction marks a sharp transition from dependence to independence in neural differentiation. The terms used here to refer to pre-differentiation status (autonomy, plasticity, limitation of potencies, etc.) are chosen to describe experimental situations, and are in no way meant to set up new verbal superstructures.

Concerning methods

Problems of the first category named above are still in a preliminary stage of investigation. Their interest lies in the future; results already obtained are mostly suggestions which have either been discussed in the first section or will be reserved for the end of this review. The methods used, however, are of great interest and warrant a paragraph here. It has already been suggested that histochemical techniques may be put to greater use. Direct physiological methods have recently reached a refinement where they can be profitably applied to the early blastoderm. Susceptibility to poisons, and differential staining with and reduction of indicator dyes had previously been the only physiological approaches (the recent book of C. M. Child reviews this work fully). Lately, Philips (1942) has measured the respiration of small pieces of the blastoderm with the Cartesian diver respirometer. Biophysical methods are available and are being explored.

The group of problems centering around the potencies or differentiation capacities of blastodermal areas has received much more attention, and will constitute the main theme of discussion in the following section. Exchange of parts between embryos has been one of the most fruitful methods of approaching these problems. In the chick, where the early blastoderm is normally under considerable tension, direct transplantation of one part to another embryo offers great technical difficulties. These have been surmounted, especially by Waddington, through the stratagem of explanting the host embryo to a plasma clot before operating. The life of such preparations is limited, but healing and regeneration are much freer than when the blastoderm is left on the yolk. Naturally there is some question as to the validity of applying the results from such preparations to normal development. Cairns (1937; also the present writer, unpublished) has obtained medullary inductions of the area pellucida ectoderm *in vivo*, quite comparable to those reported by Waddington, by using the same type of transplant. These inductions *in vivo* seem not to be as frequently obtained as inductions *in vitro* (cf. also Wetzel, 1936); they nevertheless show that the reactions of the explanted blastoderm in this connection are not abnormal.

Other experimental methods have aimed at transferring a small piece of blastoderm to some site suitable for growth and differentiation, to

determine innate reaction rather than the effect of the transplant on the new environment. The most radical of such methods is explantation *in vitro*. This method has been used extensively; it seems to furnish a rather repressive environment for small pieces of chick blastoderm, in that many differentiations seem unrealizable on a plasma clot. Nevertheless, some of our most certain information has been obtained by this technique.

More luxuriant growth and differentiation can be obtained by transplantation to the living body. In the 1890's medical investigators interested in tumor origin transplanted embryonic chick tissues in order to observe their persistence and differentiation in foreign sites. Féré (e.g. 1895, 1903) obtained successful grafts of two- to eight-day embryonic material in a subcutaneous position in adult birds; the diagrams and figures of Féré and Elias (1897) show the essential features of such transplants: mechanical limitation of the mass to an essentially spherical form, cyst formation on the part of epithelia (both ectodermal and entodermal, to judge from the figures), complete disappearance of certain tissues and clear differentiation of others. The morphology of such grafts depends partly on the original location of the tissues or their rudiments, partly on their innate capacity for persistence and specific growth. Cartilage, for example, is frequently reported as occurring in separate foci; it may even ossify. The mesenchymatous tissues, elastic, muscle, cartilage, seem most capable of persistence and development in such nodules. The young chick (Strangeways and Fell, 1926) appears to be a better host than the adult for such subcutaneous grafts.

The chorioallantoic membrane, introduced by Rous and Murphy (1911) as a site for transplantation, and first used by Danchakoff (1917, cited in 1924) to test embryonic differentiation, has rather special properties. Implanted material is surrounded, not by adult connective tissue with encapsulating proclivities, but by a loose mesenchyme framework, well vascularized and in process of healing after erosion on the part of the transplant. The blood of the nine-day embryonic host presumably fulfils more closely the requirements of young tissue than does adult blood. In any case, young blastodermal material, in pieces of suitable size, proliferates and differentiates freely, without regressing during the embryonic life of the host; it may even be retransplanted (Danchakoff and Gagarin, 1929).

Other embryonic sites of transplantation have been the body wall or the coelom of embryos on the third day of incubation. In most cases, the body wall has the disadvantage that host and graft tissues become indistinguishable after differentiation: satisfactory heteroplastic combinations have not been found. In the coelom, the transplant remains isolated, usually attached narrowly to a mesentery or to peritoneum; only its own mesenchyme is available as a framework for growth. The result is that this situation is unusually favourable for organogenesis, as contrasted to tissue proliferation (Hamburger, 1939).

Injury experiments, especially the less damaging of these, such as light electrocautery, localized x-irradiation or the transection method of Wetzel, are also to be reckoned among the methods for altering the relations of blastoderm areas. Wetzel's method, especially, is an isolation technique in which other conditions are kept strictly normal—as near to an ideal method as has been devised.

Pre-streak and primitive streak stages

Experimental study of the unincubated or pre-streak blastoderm has been attended with difficulties both of orientation and of manipulation. Ryder in 1894 reported very briefly some success in culturing previously unincubated blastoderms on the yolk, even in subdividing the germ. Some sort of unspecified aberrant differentiation was obtained. Danchakoff (1924) had negative results in transplanting unincubated blastoderms to the chorioallantois, as did Umanski (1929) later; Hoadley's (1926a, b, c) similar transplants of strips of unincubated blastoderms likewise differentiated very little, although quite good differentiation was obtained in grafts of blastoderms incubated only a few hours. Later Hoadley (1926 d), transected unincubated blastoderms *in situ* and found, in some cases, differentiation on either side of the cut after further incubation. Although these embryos were too distorted for certain interpretation, and orientation was not always clear, such results indicated a spatially pre-localized system as definitely as had the earlier injury experiments of Kopsch and Peebles. Olivo (1928) succeeded in obtaining a delayed but unmistakable differentiation of heart muscle *in vitro*, in explants isolated from the periphery of unincubated blastoderms. Murray and Selby (1930) and Butler (1935) finally obtained chorioallantoic grafts from unincubated stages. Murray and Selby demonstrated complete differentiation of such variously originating tissues as nervous system, liver, heart, and cartilage; Butler likewise found that all tissues

occurring in grafts of older blastoderms could differentiate perfectly in transplants from unincubated stages, although unincubated blastoderms formed grafts less frequently. Furthermore, she found that the posterior-median quadrant gave the same result as did the total blastoderm, but that if this area were subdivided, differentiation of axial mesodermal structures did not occur. Epithelial tubes and smooth muscle occurred in grafts from all parts; nervous tissue was found in grafts from the anterior quadrants as well as from the postero-median region. Thus the main centre of mesodermal and embryonic differentiation corresponds to the future site of the primitive streak.

Spratt (1942) found that he could obtain surprisingly normal differentiation of the embryonic axis by explanting transected blastoderms to plasma clots. Beginning with pre-streak stages, incubated a few hours, he found consistently a region approximately in the centre of the round blastoderm that would form forebrain thus in isolation; and a region between this area and the posterior border of the area pellucida that would form the rest of the axis, including medullary plate (minus forebrain), chorda, somites, and heart. A pre-localized system, where at least forebrain, including eye material, is independent of the posterior streak activities, and lies in the position determined by Assheton and Peebles, is definitely indicated. Spratt points out that the regions from which he obtains axial differentiation correspond well with the prospective area maps of Pasteels. In these transections the streak has been left intact; it must be assumed that it continues to develop *in vitro* with all the interrelations normally present. Spratt finds no essential difference when the experiment is performed on stages when the streak is present: the revealed organization is there at the time of the earliest stage used.

In contrast to these localized differentiations, where the streak-forming region has not been disturbed, Twiesselmann (1938) has been able to produce doubling or tripling of the embryonic axis by injuring the blastoderm *in ovo* somewhere near the centre of the streak-forming area. Presumably multiple streaks develop in these cases, although such development has not been observed continuously. This result can be produced only until early streak stages; later injuries result in more or less regulated half-embryos. Waterman (1936) has obtained similar results of these later stages partially bisected *in vitro*. Morita (1936, 1937) has reported the production of twins and triplets, besides monsters, in experiments where tissues of various animals (frog, rat, chick, etc.), coagulated by heat, were placed on top of the unincubated or briefly incubated blastoderm. Agar, paraffin, or colophonium were likewise effective: these at least must have produced a merely mechanical block.

The medullary reaction

The period of extreme regulability, when doubling of the whole embryonic axis can be produced by an injury, then ends while the primitive streak is still short. In the following period of streak elongation, rather special interventions are required if supernumerary parts are to be produced. It is during this time that parts of the germ have been found to be potential inductors. (This term will be used only for cases where one tissue, in direct contact with another, has been shown to alter the differentiation course of the latter.) Other blastoderm parts are competent to react to inductive stimuli by forming medullary plate. For almost all of our information here we are indebted to Waddington (1930, et seq.).

In 1933, Waddington was able, in a few described cases, to produce a supernumerary primitive streak in reversed position, by removing the hypoblast, replacing it with antero-posterior axis reversed, and culturing the whole preparation on a plasma clot. In favourable cases, two embryos resulted, one retaining the original epiblastic polarity, the other corresponding to the original hypoblast axis. This reaction was obtained only in short primitive streak stages. It must depend not only on the previously noted plasticity of the germ at this time, but also on some sort of specialization of the hypoblast in the streak region, possibly of the mesoderm adherent to the hypoblast. Waddington rejects this latter possibility for two reasons: 1) very little mesoderm does so adhere on removal of the hypoblast; 2) invaginating material at this stage becomes lateral mesoderm, which is not an inducing agent. This latter argument, not necessarily valid as a proposition, is also irrelevant because the action in question is that of causing linear invagination, not of inducing medullary plate. Waddington states that the effect of the rotated hypoblast has been to 'induce' a set of form-building movements in the originally anterior epiblast, leading to the development of a reversed primitive streak. He makes no suggestion as to the nature of the 'induction' mechanism. One night think that if, as observation suggests, invagination is a transmitted progressive response, a very few cells

in the posterior hypoblast would be an adequate trigger to set off an already present mechanism, and that a few loose early streak cells would so serve.

A variety of transplantations of tissues in embryos cultivated *in vitro* has been reported by Waddington. Pieces of the primitive streak transplanted beneath the ectoderm of primitive streak stages will induce neural tissue: in the best cases, whole axes including head and trunk. Woodside (1937) has shown that the epiblast at the short primitive streak stage is (*in vitro*) at the height of its competence to respond to the inducing influence of primitive streak tissue, by producing neural differentiations. The graft, if it includes the anterior part of the streak, usually forms neural tissue as well as mesoderm; the latter may be assimilated into the induced axis; host and graft tissues cannot always be distinguished. The anterior and middle thirds of the streak have inducing capacity; also axial pieces anterior to the node in head-process stages, and pieces of the differentiated axis which include medullary tube. Differentiated chorda has not produced unquestionable inductions, although Woodside shows some evidence for an inducing power in early chorda. Anterior primitive streak pieces coagulated by heat have produced diverticula from the host axis which are probably inductions. Duck primitive streak will induce axes in chick ectoderm and *vice versa*, and there is some evidence that rabbit primitive streak has inducing capacity for the chick ectoderm. Abercrombie (1939) has obtained positive results from some, although by no means all, of the carcinogens and other agents known to be effective in the Amphibia.

All pellucid area epiblast, in Waddington's experiments, has proved capable of forming not only neural tissue but, in good cases, a recognizable head, with the aid of the graft material. Woodside has added the information that the quantity and quality of inductions diminish progressively from short primitive streak stages through head-process stages, when this particular competence is evidently lost. The ectoderm of the opaque area shares the competence to form neural plate at least (Waddington, 1934).

In a converse experiment (Abercrombie, 1937; Abercrombie and Waddington, 1937), bits of prospectively non-neural ectoderm transplanted underneath the primitive streak are thereby induced to form medullary plate, and then may induce other ectoderm to neural formations. Pieces of primitive streak so treated differentiate into neural tube and mesoderm as they normally would.

Mechanical effects on the part of both host and donor are noticeable. Grafts beneath the primitive streak are visibly drawn out by the movements of the host. Developing grafts of primitive streak in other regions have an elongating tendency of their own, seen clearly in the cinematographic frames reproduced by Waddington and Schmidt (1933). Even if the transplant has been oriented with axis parallel to that of the host, induced axes may form perpendicular to the host axis. The orientation is a resultant of several mechanical effects: interference with host movements, even to the extent of splitting or shifting the host axis; and a strong tendency of grafts near the host axis to be drawn toward the latter, often producing inductions united with the host.

These experiments show that the conditions for formation of neural plate in the chick parallel those in the Amphibia. Any ectoderm can respond to the induction stimulus; so far, no other layer than ectoderm has responded in the neural direction. The material in the living gastrula capable of giving the stimulus is, as far as is known, restricted to the invaginating zone, i.e., to the streak with the possible exclusion of its most posterior part. In post-gastrulation stages, axial derivative tissues (medullary plate, and possibly chorda) acquire inducing capacity. Non-streak material may acquire inducing power by lying for a time underneath a developing streak.

In the induction experiments performed, the situation is always more complex than simply a reaction of ectoderm to form supernumerary medullary plate. Frequently some antero-posterior polarity is apparent in the induced structure. Foregut, as well as suitable mesoderm — chorda, mesenchyme, somites, even heart — may form in the area pellucida from host tissue in conjunction with the transplant. Thus Waddington (W. and Schmidt, 1933) distinguishes between the evocating action of the transplant, and the individuating action of the host field or reaction system. It has not been possible to disentangle the role of the transplant in differentiation; its tissues must be considered part of the reaction system also. The polarity of induced structures is determined sometimes by the transplant, sometimes by the host; evidently proximity to the host axis is one factor

determining the degree of dominance of host polarity. The exact role of each component tissue in such complex inductions cannot of course be ascertained by morphological post-mortem study. The only specific induction relation of which we are sure is the primitive streak - medullary plate one; the primitive streak is of course itself a complex of prospective tissues of unanalyzed relationship.

It will be of interest here to consider the information available from various types of isolation experiment, on the status or organization of the neural anlage during this period. In the experiments of Spratt (1942), where blastoderms were transected at different levels and then cultivated *in vitro*, it was clearly shown that a part of the prospective medullary plate (forebrain) can differentiate even if separated from the region of the streak before that structure has made its appearance. Exactly the same result for late stages was obtained by Wetzel (1936) by means of transections *in situ*. In all of these cases, the streak region carried out its differentiation, forming a complete axis lacking only the forebrain. In the posterior isolates, the medullary plate can be interpreted as arising by induction as invagination progresses; in the isolated forebrain areas the interpretation is not easy. In the pre-streak cases it is certain that no material invaginated by normal streak routes has underlain the ectoderm. The situation has been even more strikingly illustrated by experiments on early (pre-groove) primitive streak stages (Rudnick, 1938b) in which the prospective ectoderm was roughly separated from the future still superficial mesoderm and from the invaginating region itself, and the three areas cultured separately. In such cases, medullary plate would frequently differentiate from the ectodermal piece, clearly without having been underlain by mesoderm and without contact with the streak. On the other hand, the isolation of the invaginating region from the material immediately surrounding it prevented any effective differentiation of the trunk axis. In slightly later stages, the region immediately adjacent to the streak could differentiate as medullary plate also.

Forebrain, as a complex including eye, is thus localized and independent of posterior material in pre-streak stages. Properties manifested in this partial isolation include formation of medullary plate and its closure to a tube or vesicle. The latter process was long ago (1885) shown by Roux to follow when medullary plate of the chick is isolated by cuts from lateral ectoderm. Hobson (1941) has recently reproposed differential water imbibition as a closure mechanism.

In the experiments of Spratt, recognizable forebrain parts, such as optic vesicle, developed from the primary tube. Furthermore, differentiation of cells to form neuroblasts or pigment elements can follow primary morphogenesis. The individual components of the forebrain complex, nevertheless, are not irrevocably localized until much later. According to Clarke (1936), median forebrain tissue can form retina in grafts even in early somite stages; while the parts of the retina remain plastic long after the optic cup is formed (Alexander, 1937; Dorris, 1938). Wolff (1936) finds the head-process stage most favourable for producing true cyclopia by irradiation of the forebrain area — a result obviously requiring much reallocation of material in the anterior medullary plate.

A general localization of more posterior brain levels around the node has been indicated by Hunt (1931, 1932) in graft experiments on the definitive primitive streak stage. In blastoderm stages, underlying mesoderm has always to be included in a transplant of ectoderm, so that the actual residence of this regional organization is not certain. The differentiation capacity of the prospective medullary material posterior to the node is slight when tested in chorioallantoic grafts (Hunt, 1932; Dalton, 1935), but is somewhat better expressed when isolation of the posterior blastoderm is made *in vitro* (Waddington, 1935; Rudnick, 1938c) or *in situ* (Wetzel, 1936).

That the prospective neural tube is by no means a mosaic when tested by isolation methods is emphasized by the differentiation of melanophores in isolates from all prospective neural regions in definitive primitive streak and head-process stages (Rawles, 1940) when the pieces are grafted to the flank of an older embryo. This potency is present likewise in pre-streak stages (Spratt, 1942). Melanophores are one characteristic differentiation of neural crest (Dorris, 1936, 1939); thus this particular histogenetic potency is at first diffuse throughout the prospective medullary plate, and only later localized in its periphery (Ris, 1941).

Other neural structures are not sufficiently autonomous to differentiate in isolation until somite stages. Olfactory placode becomes capable of differentiating in the presence of forebrain in the 9–12 somite stage, when grafted (Street, 1937);

it does not differentiate in the absence of brain until much later. Ear placode acquires independence at the 15–20 somite stage (Waddington, 1936); hypophysis, toward the 9-somite stage (Stein, 1933). In the case of the ear, it is clear that the structure acquires autonomy only gradually, under the influence of several adjacent tissues. This may prove to be the case with other placodal structures as well.

These experimental indications do not lead directly to a simple theory of the origin and organization of the medullary plate. The easiest assumption to make is that at the beginning of incubation the ectoderm is a polarized system competent to form medullary plate; that the immediate inductive stimulus normally is given in the proper region by a certain portion of the invaginating or invaginated mesoderm: the axial or chorda-somite portion. At present this is a most probable interpretation, although the peculiarities of the primitive streak have prevented its being directly shown that the induction of neural plate in normal development is associated with the underlying of ectoderm by mesoderm. It may be that other contact relations are effective. Furthermore, it seems probable that there is unconformity between the prospective somite and medullary regions posterior to the node (Wetzel, 1929; Wolff, 1936).

A difficulty comes in understanding the most anterior medullary material, which can differentiate without contact with the primitive streak. Two general possibilities suggest themselves: 1) that in isolated anterior blastoderm portions, although no primitive streak formation takes place, there nevertheless is some sporadic invagination or delamination of mesoderm cells (the 'early free mesoderm' of Wetzel) which furnishes stimulus for medullary differentiation; and that such mesoderm is the normal inductor for forebrain. The second possibility is that the prospective medullary plate is prelocalized in the ectoderm as a region more competent to form medullary plate than is the remaining peripheral ectoderm; and that this medullary area has within itself graded properties, ranging from perhaps complete autonomy in the antero-central region to complete dependence peripherally and posteriorly. There are difficulties in accepting either view. The forebrain, as has been recognized by Kingsbury (1920, etc.), is the only part of the neural tube originating morphologically without including any of the original neural floor. Thus it must be classified with the lateral or peripheral medullary plate, as against the axial part originating directly from the node in primary body development. It is possible that this distinction indicates a truly fundamental difference in mechanics of origin as well as in prospective significance.

Once in position and having undergone induction, the medullary plate is by no means isotropic. Major regions seem to be laid out very early—in the case of the forebrain, before the final spatial relations are established. At first, each major field or level is probably isotropic within itself; only later do mediolateral and other differentials become fixed. The forces at work in these pattern fixations may be of the nature of cooperative inductions in the case of extramedullary placodes. In the case of intramedullary or neural crest pattern, the field for speculation is entirely unencumbered by experimental facts. Some of the forces must be of a nature to involve large cell groups or areas, as when the outer layer of the optic cup produces pigment; others must be operative in individual cells, as when occasional neural crest cells slip along beneath the ectoderm to become melanophores.

The lens

The lens is one other ectodermal structure originating in the early period, concerning which information is available. Waddington and Cohen (1936), in operations performed *in vitro*, have had results suggesting that lentoids at least may be induced in primitive streak ectoderm that would not normally form lens, by transplants of optic vesicle; and that such induction is less effective the greater the distance from the host eye region. After removal of the optic vesicle, its overlying ectoderm is able evidently to form only a lentoid. The fact that, in the transplantation experiments, neural inductions were obtained in some cases instead of the expected lenses, may be a confirmation of the thesis of Lillie (1929) that at a certain stage ectoderm can respond to any inductive stimulus only by a neural reaction. Van Deth (1940) also reports a beautiful example of neural induction by an optic cup transplanted to a thirty-six hour host.

Alexander (1937) transplanted optic cups or parts of cups to various positions beneath the ectoderm of embryos in early somite stages, *in ovo*. His results show that there is a definite ability of the host ectoderm to form lens when properly

stimulated, and that this property decreases with distance from the optic region, as well as with increasing age of host. Interpretation is complicated by the frequent regeneration of lenses from the grafted retina, and by several enigmatic cases where a lens was found connected with both ectoderm and graft, suggesting its possible origin from an injury blastema.

Van Deth (1940) has obtained more extensive results on material cultured *in vitro* in various ways. He finds that ability of lens ectoderm to differentiate independently is acquired gradually, during the period of primary contact with the optic vesicle. The optic cup is the unique inducing agent in this case; ectoderm from anywhere in the body can respond to the stimulus until after the second day (later than reported by Alexander); subsequently the response becomes restricted to the corneal region, which is able to form lenses at least as late as the fifth day of incubation. Van Deth finds that lenses can also originate by regeneration from the iris border or the retina, as well as from corneal ectoderm, during at least the second and third days of incubation. The occurrence of such regeneration is of course a complication in the interpretation of any transplanted material, and a great objection to the use of the eye chamber as a site for testing differentiation.

Mesodermal anlagen

In chorioallantoic grafts of primitive streak and head-process blastoderms, mesodermal and entodermal tissues differentiate fully, usually in regional complexes, along with ectodermal material. That these potencies are spatially localized was established by Hoadley (1926 a, b, c), Hunt (1931, 1932 a, b), and Dalton (1935), testing separately different levels of the antero-posterior axis, and by Rudnick (1932, 1935), and Clarke (1936) for the medio-lateral axis. Such studies were carried to their logical end by Rawles (1936), who transplanted separately eighteen different pieces of the head-process blastoderm, and clearly established, in one coherent set of experiments, the regions or levels of specific potency for such tissues as central nervous system, heart, liver, thyroid, mesonephros, gonad, and intestine (cf. also Willier and Rawles, 1936). The localization of many of these areas corresponds in a general way to the prospective significance maps of Wetzel and Pasteels. Each area seems to have a center of strong differentiation capacity which diminishes peripherally. These results indicate a pattern either of intrinsic potencies, or of localized correlative factors, but do not offer direct evidence in favor of either alternative.

Tissue culture offers a more selective environment. From early streak stages on, certain mesodermal structures differentiate in this medium, whereas others have difficulty. According to the scheme of Pasteels, the first invaginated material should move peripherally and become extraembryonic; hence the early primitive streak should differentiate as blood if it possesses any degree of self-sufficiency. This actually occurs (Rudnick, 1938b); but later primitive streak as well as other early blastoderm regions can also form erythrocytes (Murray, 1932). This differentiation must depend not on a localized anlage, but on more general conditions.

Heart and lateral plate should be the next material invaginated. This seems to be true of heart muscle (Rudnick, 1938 a, b), which differentiates also in peripheral explants from unincubated blastoderms (Olivo, 1928). In early streak stages, pulsating heart muscle develops from an area just peripheral to the streak; later, from the streak itself; still later, from discrete areas on either side of the node. These results indicate a migration of something very definite, and may be taken as demonstrating a marked degree of autonomy. Rawles (1943) has recently contributed precise information on the extent, mainly in head-process stages, of the laterally placed heart-forming areas —the test being made in chorioallantoic grafts as well as by culture *in vitro*. The areas have proved to be amazingly large, exceeding in size the actual myocardial anlagen. Thus it is made certain that the areas of heart potency tested in grafts include more than prospective heart, and that a considerable share of heart formed in grafts may be a *bedeutungsfremde* differentiation.

In the case of lateral plate, the evidence consists of differentiation in chorioallantoic grafts of coelomic sacs containing remarkably normal segments of intestine. These are found in grafts of material closely posterior to the node in the definitive primitive streak stage, much farther back in head-process stages (Rawles, 1936; Rudnick and Rawles, 1937). Occurrence in grafts of such organized complexes tells very little about the individual components. Knowledge of the limb-forming areas of the lateral plate is similarly restricted. No differentiation of recognizable limbs

has been reported before the pre-somite stage; at this time, it is probable that the mesoderm and ectoderm have established contact. A relatively large piece of material of suitable level is capable of forming wing or leg respectively, in coelomic grafts, during the development and closure of the sinus rhomboidalis (Rudnick, 1942, 1944).

The next material to reach the streak and to invaginate should be the nephrotome. Hoadley (1926) has described some cases of nephric tubules and glomeruli in grafts from various parts of early blastoderms; these transplants probably all included the anterior end of the streak or streak-forming region. Rawles (1936) found mesonephros and gonad to originate from a region rather close behind Hensen's node in the head-process stage (for review cf. Willier, 1939). Again, these results cannot be taken as proof of autonomy. In the case of the metanephros, no differentiation of its tissue has been obtained before the stage when the ureters unite with the nephric blastema (Seevers, 1932).

The chorda-somite mesoderm has not been dealt with in isolation. Derivative tissues are of course found in grafts and explants from the streak complex. Some exceedingly interesting information on the primitive morphogenesis of this mesoderm has been obtained by Wolff (1936), who by means of a carefully controlled technique of exposure and screening has achieved the x-irradiation of very small regions of the blastoderm. When Hensen's node, in primitive streak or head-process stages, is subjected to this exposure, and the embryo allowed to incubate until the third day, a differentially restricted lesion may occur. In the cases figured by Wolff, the procedure has been radical enough to prevent development of the chorda posterior to the irradiated region. At this level, the nerve tube likewise may be interrupted, or reduced to a necrotic mass or plate; the somite material tends to form a median segmented mass. Behind the necrotic region (at the tenth to sixteenth somite level, according to the illustrations), a superficially normal axis reappears. Sections show that here the chorda is wanting and the nerve tube is of abnormal form, whereas the somites appear normal. Thus the chorda and neural floor appear to have been completely inactivated, whereas the other functions of the anterior streak have been surprisingly little interfered with. The unimportance of the notochord for posterior inductions and arrangement is striking. One cannot agree with Wolff that one function of the chorda is to separate somite material on either side of itself, in view of these posterior axes where the somites are normally placed without a trace of chorda between.

Chorda has never been shown to differentiate from other than the node region. Somite derivatives are not specific enough to be subjected to a similar histogenetic test. In grafts, skin, skeletal muscle, and cartilage are found to differentiate from the anterior half of the streak and from material lateral thereto. Murray (1928) has pointed out that in grafts, dermis clearly can differentiate from lateral embryonic regions from which somites have been excluded. In view of the recent work of Lillie and Wang (1941, 1943) and Wang (1943) showing the importance of the dermis in the organization of the feather papilla, the origin and mechanics of this layer would seem to merit more thorough study than has heretofore been accorded them.

Entoderm

The hypoblast has so far refused to differentiate independently *in vitro* or in grafts (Waddington, 1932; Waterman, 1936; Hunt, 1937a). Its cells seem incapable of developing unless mesoderm is present. In grafts containing mesoderm, differentiation of entodermal structures is almost always associated with the corresponding mesodermal region, i.e., liver and thyroid with heart (Willier and Rawles, 1931; Rudnick, 1932), intestinal mucosa with its mesodermal tunics. Hunt has performed an extensive series of grafts, showing differentiation of gut to occur in the absence of hypoblast, at least until head-process stages. In primitive streak stages, the anterior streak epiblast forms entodermal structures representing all levels, whereas posterior streak and lateral epiblast tend rather to form posterior components, i.e., intestine. Heart likewise is found in these grafts.

In general, Hunt's results for primitive streak stages show a system in which, as tested, components of the three germ layers are not fully sorted out. Undoubtedly the process of invagination of the mesodermal areas is thus revealed, and possibly also that of entoderm. The differentiation capacities, especially of the streak region, seem far greater than would be allowed by the Pasteels map if the differentiation were merely a realization of prospective significance on the part of the germinal areas. Whether or not differentiation of gut in these grafts is best explained by the presence in the epiblast of the actual cellular material of both mesodermal and entodermal layers, remains an open question.

If the alternative explanation be considered, it implies some sort of dependence of entodermal structures on adjacent mesodermal areas for their differentiation. There may be a series of induction relations here that would distinguish the *Entwicklungsmechanik* of the chick gastrula sharply from that of the amphibian.

CODA

In summary of the considerations on the foregoing pages, Figures 9 and 10 have been prepared, in spite of much hesitation at further mapping the many-times-mapped chick blastoderm, and with full realization of the hypothetical nature of some of the adaptations made. Figure 9 shows differentiation potencies at the definitive primitive streak stage. Lateral and posterior boundaries of potential areas have by no means been determined, as the scattered figures are meant to indicate. The listing of ectodermal derivatives on the left side and mesodermal on the right is purely for convenience, since no experiments at this stage have separated the two layers.

The main source of information has been the experiments of Hunt, testing streak and lateral regions of the epiblast in chorioallantoic grafts; some additions or confirmations have been drawn from the work of Rudnick (1932), of Dalton (1935), as well as from that of Rawles (1940) on transplants to the young embryo, and of Rawles (1943); and from the tissue culture experiments of Murray (1932). The major result which emerges is the correspondence of the main differentiation potencies in the central nervous system with the vital-stain maps as regards antero-posterior arrangement, in contrast to the concentration and coincidence of mesodermal and entodermal differentiation potencies around the anterior end of the primitive streak. This map should be compared with the potency maps of head-process stages published by Rawles (1936) and Willier and Rawles (1935). The lateral and posterior spread of mesodermal areas in the latter stage is striking. We have no data on mesodermal migration that will tell us how far this change may be ascribed simply to movement of cellular areas. Unless the Pasteels map for primitive streak stages is very wrong, and the mesodermal areas do not emigrate from the streak in the orderly fashion he indicates, differentiation of heart and intestine and more especially of melanophores and erythroblasts must to a considerable extent be explained as *bedeutungsfremde* in the stage mapped.

A possibility that should be examined is the suggestion of Wolff (1936) — also considered a possibility by Wetzel — that the primitive streak even as it regresses continues an appreciable amount of invagination. Figure 10 is a modification of the Pasteels map to show the shape of areas under such an assumption. The further arbitrary assumption has been made that this late invagination is limited to prospective embryonic material and does not occur in the posterior streak. The neat delimitation of areas in the amassed cells of the streak is of course a convention, as is the indication that material always remains on its own side of the midline after invagination.

Even on this basis, the only mesodermal region the prospective significance of which corresponds with its prospective potency remains chorda. At this stage of our knowledge we must therefore conclude that the experimental environments in which blastodermal isolates have been tested offer conditions which permit a multiplicity of differentiation in some cells, and inhibit some or all differentiation in cells from other areas.

The greatest complications, obviously, are in the primitive streak. The act of invagination, in addition to its morphological and cytological effects, must perform a startling number of things, of which the release of whatever induces medullary plate is but one. These cells must themselves be in an extraordinarily labile state, capable of overproduction or of being suppressed in foreign environments.

Some of the unique properties of the streak have been made patent by susceptibility experiments (Hyman, 1927) or by differential reduction of vital dyes (Rulon, 1935). The strict physiological significance of these effects is elusive; nevertheless, the experiments all indicate properties of the primitive streak not shared by the rest of the blastoderm. That aerobic respiration is not an item of this differential has been demonstrated by Philips (1942) for the head-process blastoderm. Respiration of course is only one of many cellular processes now known and available for exact determination with micro-methods, and we may hope in the future for precise biochemical information on what primitive streak cells do. Meanwhile, some embryologists would do well to remember that morphodynamic relations in the primitive streak need much clarification before the problem can be handed over in one neat package to the biochemist. It is in this connection and purely as an experimental target that Figure 10 is presented.

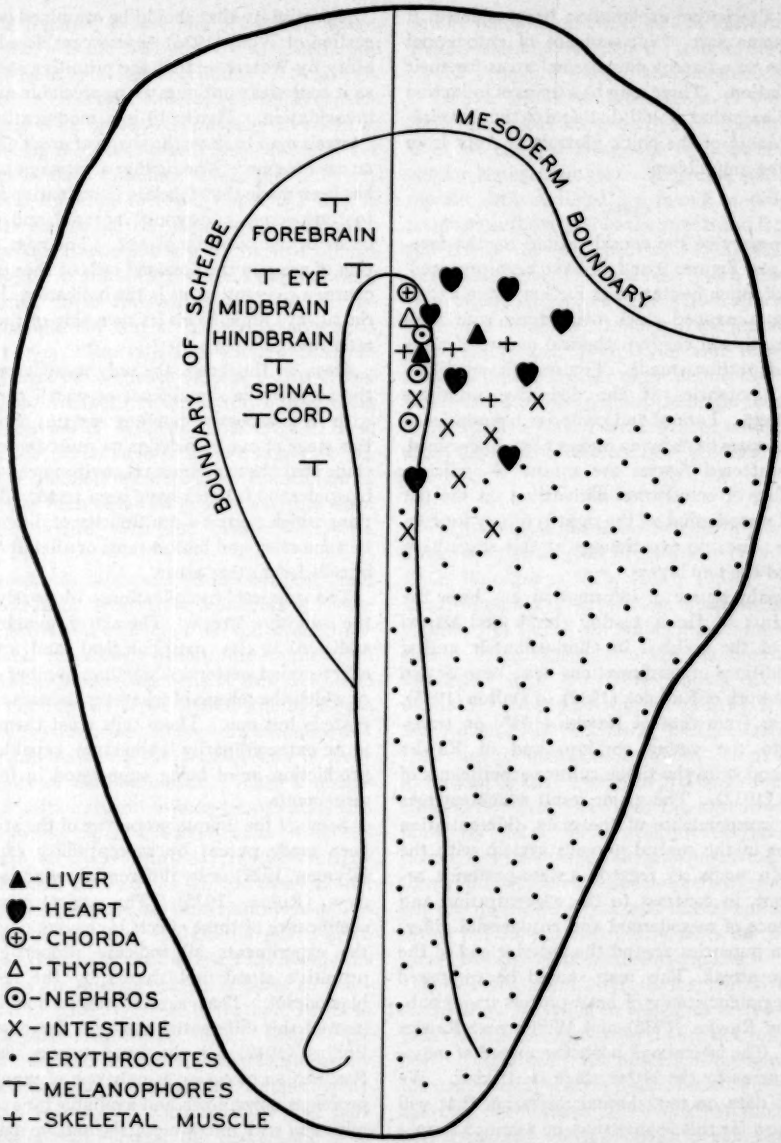

FIG. 9. DISTRIBUTION OF POTENCIES IN THE DEFINITIVE PRIMITIVE STREAK BLASTODERM, TESTED UNDER VARIOUS EXPERIMENTAL CONDITIONS

Ectodermal potencies shown on left, mesodermal and entodermal on right; these have not been tested separately. Posterior and lateral extent of mesodermal potencies has not been specified.

Material in this review has made clear that some of the properties of the primitive streak cells (i.e. certain differentiation potencies) antedate the formation of the primitive streak itself; probably others are acquired as the cells flow into or are amassed in the streak. In this connection, the

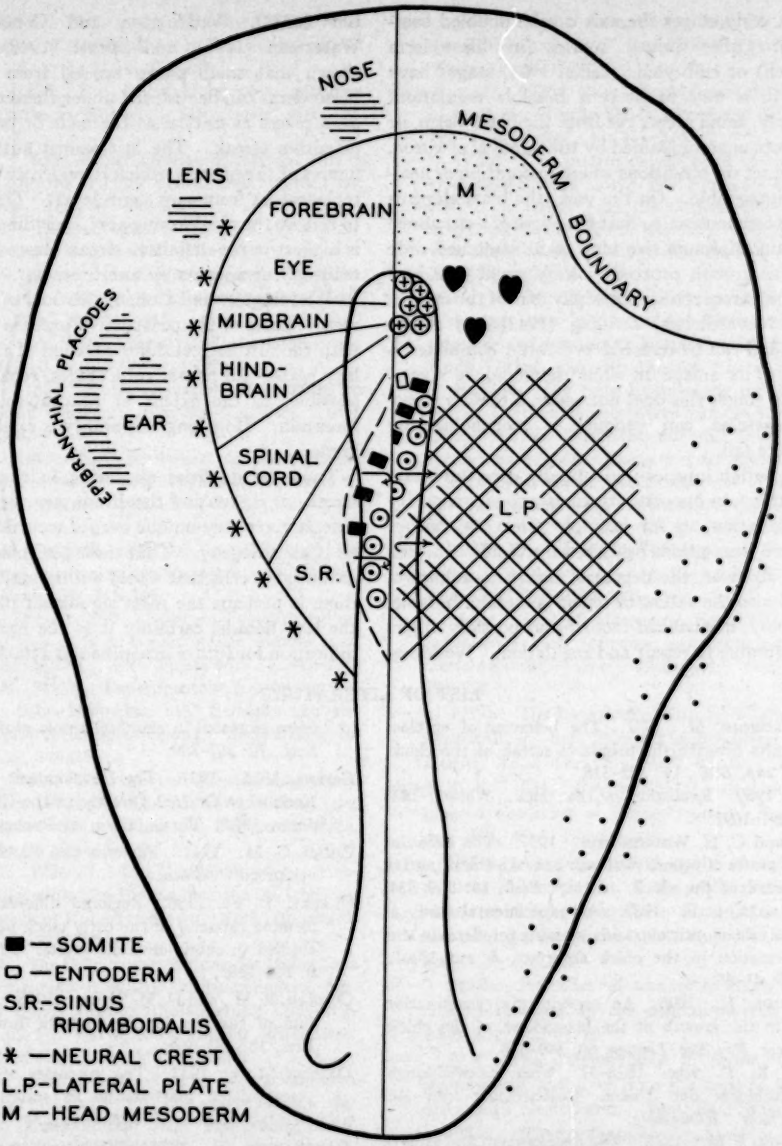

FIG. 10. PROSPECTIVE AREA MAP OF THE DEFINITIVE PRIMITIVE STREAK BLASTODERM
Superficial layer shown on left, invaginated material on right. Posterior and lateral site of lateral plate-blood junction very uncertain.
(Mainly after Pasteels, with suggestions from Wolff and from Yntema, and embellishments by the present author.)

regulability of the blastoderm in early stages must be considered; some information regarding this is available.

Injury experiments on the intact blastoderm have revealed surprisingly little capacity for regulation. Only the work of Twiesselmann shows

that in early stages the axis can be doubled completely. Other injury marks, in blastoderm (Kopsch) or embryonic (Lillie, 1904) stages have acted in a way to prevent possible regulation. Similarly, small pieces cut from the blastoderm, or even cuts unaccompanied by the removal of tissue, usually set up conditions where restoration or healing is impossible. On the yolk, the blastoderm is under some tension, so that the edges of a cut above a certain minimum size tend to be stretched wide apart as growth proceeds. Very small cuts heal without a trace; this is especially true of the opaque area. Nevertheless, Zwilling (1942) has shown that a tail can be restored even after complete removal of its anlage in sinus rhomboidalis stages. In later stages this does not occur, although a partial blastema can produce a morphologically complete tail.

Irradiation injuries undoubtedly give the intact blastoderm an opportunity to exercise its capacity for regulation, as for example after the various localized irradiations practiced by Wolff. In such cases, however, the degree of injury is unknown, and so also the extent of repair is undeterminable.

In vitro, mechanical factors and possibly others are favorable to repair and regulation. Waddington (1932), Waddington and Cohen (1936), Waterman (1936), and Spratt (1940) have all shown that small pieces excised from the early blastoderm can be restored under these conditions, even pieces as critical as the node or parts of the primitive streak. The last-named author shows figures of the process, which is evidently an orderly replacement from each germ layer. The capacity to restore the eye-forming area, including the node, is highest in pre-definitive streak blastoderms, and evidently disappears by somite stages. According to Waddington and Cohen, this loss of ability to restore parts of the prospective brain is correlated with the histological differentiation of the medullary plate. In neural tube stages, repair is again possible, to the extent of restoration of a half forebrain. How long this ability is retained is not known.

Thus the qualities appearing in the primitive streak, or emanating therefrom, are not irreplaceable, nor are they unique events occurring once for all in an ontogeny. That these phenomena can be produced in cells that would not normally manifest them is perhaps the most significant discovery of the last decade; certainly it is the most hopeful indication for future experimental attack.

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LIFE CYCLES IN THE MYXOSPORIDIA

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THE order Myxosporidia consists of a group of protozoan parasites belonging to the class Sporozoa. Infection is largely confined to marine and fresh water fishes, but a few forms are found in amphibians and reptiles. There are no intermediate hosts. Many species are located in such cavities as the gall and urinary bladders, and others are tissue parasites inhabiting gills, skin, muscles, kidneys, etc. Infection seems not to be generally harmful to the host. Classification of this group of Sporozoa is based on spore structure.

A survey of the literature reveals that there is little agreement on the details of nuclear changes in the Myxosporidia. Some authors maintain that the cycle is mainly haploid, others have described a diploid cycle. Some reports indicate that there are two reduction divisions and two zygotes in one cycle. When only one zygote is reported the reduction division in one case occurs just before fertilization, in another case it occurs just after fertilization. Some authors have maintained that there is no sexual process.

These conflicting reports prompted the writer to review the literature and evaluate the various conclusions concerning chromosome and nuclear behavior in the light of the more recent papers in the field. Also, because these parasites are among the few protozoa which possess a complex life cycle involving several types of somatic as well as sex cells, an attempt has been made to indicate wherein a study of the Myxosporidia may aid in the problem of the origin of sexual reproduction and the process of formation of a multicellular body. Finally, as an aid to the study of protozoology, the writer has made an effort to gather all the important information on this little known order.

The more important reviews of myxosporidian literature include the papers by Gurley (1894), Thélohan (1895), Labbé (1899), Auerbach (1910), and Kudo (1919). These authors devoted considerable space to taxonomy. Erdmann (1917b), Naville (1930), and Georgévitch (1935), on the other hand, have presented reviews confined to a consideration of the occurrence of a sexual process. There has been no published work which undertakes to review all aspects of myxosporidian life cycles since the monograph by Auerbach in 1910.

TERMINOLOGY

The terminology which has been in use with the Myxosporidia has been taken from well known stages in the typical life cycles of the Telosporidia. But the life cycles of most, if not all, Myxosporidia are decidedly different from those of any other group of Sporozoa. For this reason there has been some confusion in the terms used. The first step in discussing this problem is to define some of these terms.

trophozoite—the growing vegetative individual.

schizogony (*agamogony*)—the process of development ending in multiple fission during the asexual phase of a trophozoite, and resulting in the production of additional trophic individuals which may be called "merozoites" or "agametes". The significant result is the production of separate, new individuals which grow and develop into adult stages of the life cycle.

schizont—the trophozoite during the process of schizogony.

sporogony—the process by which spores or sporozoites are developed from a zygote (Telosporidia) or from a sporoblast (Myxosporidia).

sporont (*sporoblast*)—an individual or stage which is destined to develop into one or more spores, either directly by the secretion of a sporocyst membrane (Telosporidia), or indirectly by internal development resulting in one or more spores (Myxosporidia).

pansporoblast—a sporont which produces two or more spores.

sporoplasm—the vital living portion (*germ*) of the spore as distinguished from the other differentiated parts. The sporoplasm includes the *sporoplasm nuclei* which are the *gametes*.

sporulation—the formation of spores by a process of multiple division. This process is called *sporogony* when it follows sexual fusion.

synkaryon—the nucleus of a zygote.

gamogony—the process by which one or more gametes are produced from a gamete-mother cell (i.e. from a gamont or gametocyte).

plasmotomy—the division of a multinucleate body into smaller, separate bodies. This cytoplasmic division is independent of nuclear division.

plasmogamy—the cytoplasmic union of two or more cells. The nuclei of the cells remain distinct.

A typical example of schizogony in the class Sporozoa is the process of merozoite development of *Plasmodium* from sporozoites which enter the blood stream of the vertebrate host. Each merozoite enters another red blood cell to grow and develop into either another trophic individual or into a gametocyte. Schizogony has been described for a number of genera of Myxosporidia, but a study of these descriptions reveals that multiplication is accomplished more by budding or plasmotomy than by multiple fission. The position in the life cycle of this multiplicative phase, however, is not the same as the position of schizogony in the Telosporidia. Schizogony in the latter group occurs immediately before the formation of gametes and fertilization. But in the Myxosporidia multiplication occurs immediately after the zygote is produced, and it is thus in the sexual phase of the cycle. In the Telosporidia the zygote enters upon sporogony rather than schizogony. Thus schizogony in the Telosporidia is not homologous with budding in the Myxosporidia, and the term "schizogony" is not applicable to the budding process.

Most of the descriptions of life cycles in the Myxosporidia belong to those genera which develop large multinucleate and polysporous trophozoites or cysts. In these species true schizogony rarely, if ever, occurs, although the term has been erroneously adopted by most authors in this field. A typical example is found in *Myxidium gasterostei* (Noble, 1943). The zygote of this species does not divide as a whole, but its nucleus (the synkaryon) and the succeeding daughter nuclei divide. These divisions are accompanied by cytoplasmic growth until a large multinucleate cell is produced. The nuclear divisions of this phase correspond in position to the budding and plasmotomy described for the other type of myxosporidian life cycle. In the former case, however, no new individuals are produced. The original trophozoite simply grows. The conclusion must be made that in the Myxosporidia schizogony is either represented by budding and plasmotomy, or it does not exist.

There has been no appropriate word to describe the process of the formation of a multinuclear cell from a uninuclear cell. Because this process results in the production of nuclei, I suggest the term *nucleogony*.

The life cycle of a myxosporidian parasite begins, then, with the zygote, and it is continued by a process of nucleogony and cytoplasmic growth. In some species (chiefly in the families Ceratomyxidae, Sphaeromyxidae, and Chloromyxidae) nucleogony is accompanied by budding or plasmotomy. More often nucleogony and cytoplasmic growth lead directly to the formation of spores.

Sporogony, as defined, is the production of spores or sporozoites from a zygote or from a sporoblast. This process is the sexual phase of the telosporidian life cycle, and a typical example is the spore formation of *Eimeria* or, in the Haemosporidia, the sporozoite formation of *Plasmodium* in the body of a mosquito. In each case the entire sporogony phase is completed within the single, original membrane.

In the Myxosporidia, sporogony is often described as beginning with a pansporoblast. As indicated above, a marked distinction has usually been made between a "schizogony" and a sporogony phase of the life cycle. This distinction is perhaps a logical one in the disporous species, such as in the Genus *Ceratomyxa*, where, because of budding, numerous trophozoites are derived from the zygote. But here sporogony can be traced directly from the zygote, and the budding cycle is merely a secondary process (fig. 1). Many life cycles have been diagrammed as if the asexual multiplicative phase were quite apart from and independent of sporogony. Asexual multiplication in the Myxosporidia, whether budding or plasmotomy, should be considered a secondary process accompanying spore production.

In the polysporous genera, such as *Myxidium* and *Myxobolus*, the entire life of the trophozoite is a combination of sporogony and nucleogony. All stages of the cycle are developing at the same time, and mature spores are constantly being produced (fig. 2). The presence or absence of asexual multiplication (budding) in the Myxosporidia is not as significant as it is in the gregarines where the order is divided into two distinct groups (Schizogregarina and Eugregarina), based on the presence or absence of schizogony.

To summarize the conclusions regarding the use of terms—True schizogony does not exist in the

Myxosporidia. Asexual multiplication occurs in monosporous and in some disporous species in the form of budding or plasmotomy, but this multiplication is a secondary process accompanying spore production. The entire life cycle of the large

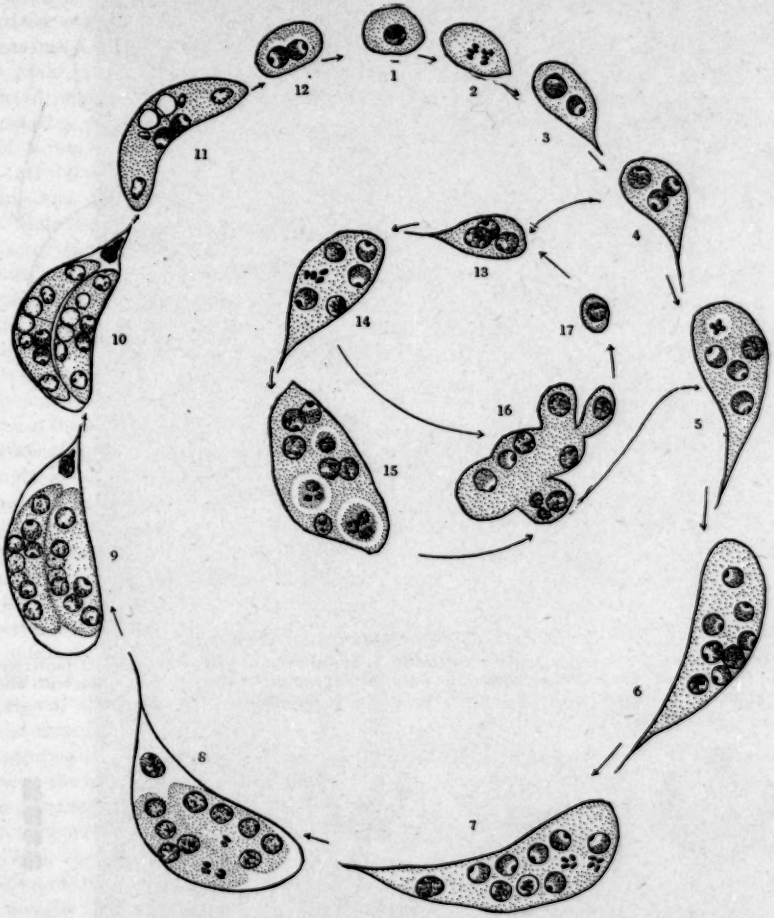

FIG. 1. LIFE CYCLE OF CERATOMYXA BLENNIUS

1, zygote; 2–11, sporogony; 8, two sporoblasts showing reduction division; 9, young spores; 11, mature spore; 12, sporoplasm with gametes; 13–17 nucleogony with cytoplasmic growth and budding; 15, internal budding; 16, external budding; 17, uninucleate bud.

(From Noble, 1941. Courtesy, The Wistar Institute)

polysporous species generally occurs within the original zygote membrane. Multiplication in these polysporous species is accomplished largely by nucleogony and cytoplasmic growth. Nucleogony takes place simultaneously with and in addition to sporogony.

MITOSIS

The typical myxosporidian nucleus contains a large, eccentric karyosome and peripheral chromatin. Most accounts of mitosis describe the formation of centrioles from the karyosome. Although the whole karyosome may form the centrioles (see Georgévitch, 1929, on *Ceratomyxa menae*), more often they are produced by the pinching off of a small part which subsequently divides (see Keysselitz, 1908, on *Myxobolus pfeifferi*). The remainder of the karyosome usually disintegrates either

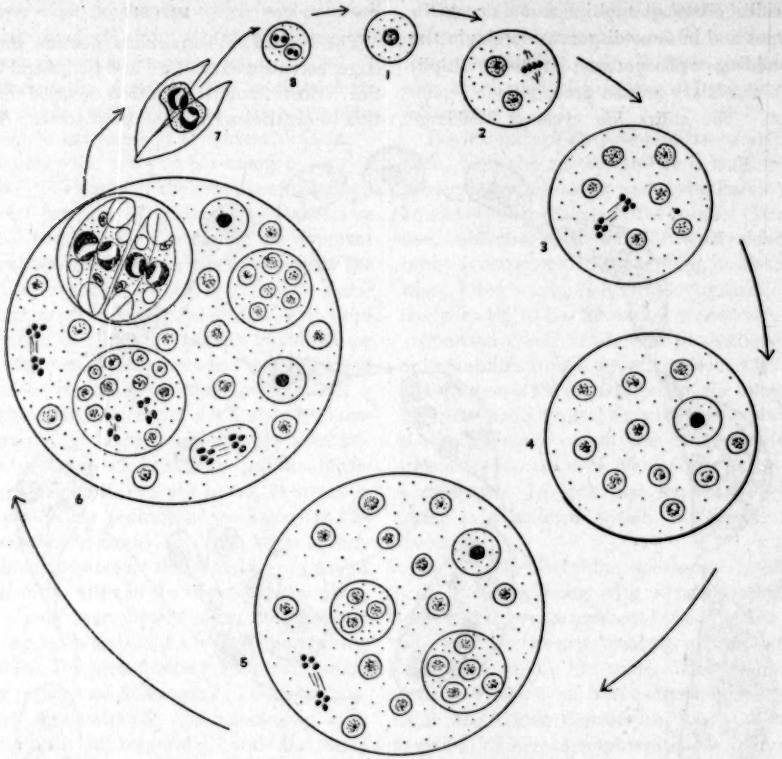

FIG. 2. LIFE CYCLE OF MYXIDIUM GASTEROSTEI

1. Zygote; 2–3, nucleogony and cytoplasmic growth; 4, appearance of first pansporoblast (enlarged cell); 5, nucleogony, cytoplasmic growth and sporogony; 6, formation of mature spores; 7, sporulation with liberation of amebula containing two haploid nuclei; 8, isogametes just before fertilization.

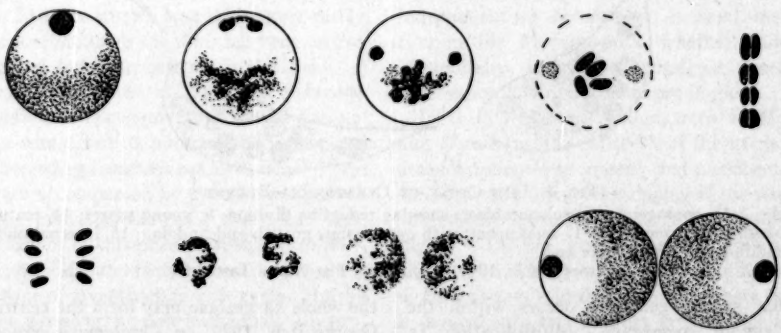

FIG. 3. MITOSIS IN CERATOMYXA BLENNIUS

Note abortive centrioles formed from the karyosome (Modified from Noble, 1941. Courtesy, The Wistar Institute)

while the chromosomes are being formed from peripheral chromatin or just after the metaphase (fig. 3). Centrioles are often abortive and spindle fibers may be formed.

In *Ceratomyxa drepanopsettae* the karyosome, which is in the form of a crescent, divides to form two centrioles which migrate to opposite sides of the nucleus but remain connected with a centrodesmose while still surrounded by the nuclear membrane (Awerinzew, 1909). Georgévitch (1935) also described a centrodesmose between the two halves of a karyosome bud. Four chromatin threads are produced from the peripheral chromatin, and become shortened into chromosomes while the karyosome and its buds disappear. Georgévitch (1916b, 1917) described a "promitosis" preceded by a division of the karyosome, but without a trace of centrosomes. In *Zschokkella rovignensis* the haploid chromosomes of the sporoplasm nuclei are fused with the karyosome (Georgévitch, 1936). This condition is similar to the union of peripheral chromatin and the karyosome in the initial stage of the pansporoblast of *Myxidium gasterostei* (Noble, 1943).

The function of the karyosome has not been determined, nor has its origin been clearly demonstrated. Bremer (1922) thinks it probable that the Binnenkörper (karyosome) is instrumental in the separation of daughter chromosomes during mitosis in *Myxidium lieberkühni*. Bělař (1926) has suggested that the karyosome of *Sphaeromyxa sabrazesi* aids in the formation of the polar capsules of the spore. Keysselitz (1908) and Awerinzew (1909) believed that the karyosome consists of plastin and chromatin components. Georgévitch (1935) suggested that the karyosome may partly contribute to the origin of the chromosomes. Because the karyosome is formed, at least in part, from the chromosome material of the telophase (Noble, 1941), one might conclude that it in turn, gives up part of its substance to the new chromosomes at mitosis. There is no conclusive evidence, however, that such is the case in the Myxosporidia.

In testing the nucleus with the Feulgen technique, Noble (1941) found evidence that the karyosome of *Ceratomyxa blennius* contains thymonucleic acid. More recently, with the use of Gates' (1942) method of testing for nucleolar material with a light green counterstain, the karyosomes of *C. blennius* were definitely greener than peripheral chromatin, indicating possibly a combination of nuclear and nucleolar materials. Davis (1925) called the karyosome of *Lentospora* a "plasmosome" (nucleolus), and Kudo (1923, 1926) stated that the nucleolus of *Myxosoma* is composed mainly of plastin material and should be called a "plasmosome" instead of a chromatin nucleolus or karyosome. If the karyosome represents the nucleolus of other organisms, its function may be to aid in the formation of chromosome sheath substance.

Deeply staining cytoplasmic granules have frequently been reported in myxosporidian cells, but whether they are of nuclear origin is questionable. Davis (1923) described such granules as "chromatoid bodies." Georgévitch (1916a) mentioned a fragmentation of the karyosome into several granules. Some of the cytoplasmic granules commonly observed in these cells may be derived from the karyosome, but the latter body often disappears gradually without any apparent breaking into smaller units. Kudo (1923) has described a "primitive mitosis," in *Myxosoma catostomi*, where the generative nuclei throw off much "plasmosome" material from the nucleoli. The plasmosome forms the spore membrane.

Almost all species of the Myxosporidia have four chromosomes. In some forms the peripheral chromatin first gives rise to coiled threads which then shorten and become straightened, whereas in others the peripheral chromatin simply condenses into irregular clumps which then develop into the four chromosomes. There has been no reported attempt to study the details of chromosome structure in these parasites.

AMITOSIS

Amitosis has been described for a number of myxosporidian species. The writer has frequently observed the division of small trophozoite nuclei which appear to be without chromosomes, but some of these nuclei are only two or three microns in diameter, and the recognition of distinct chromosomes in them would be exceedingly difficult if the chromosomes were not widely separated. Many authors have stated that amitosis "probably" or "apparently" occurs.

Kudo (1923) believed that the vegetative nuclei of *Myxosoma catostomi* divide by amitosis and give off material to help form the generative nuclei. The same author (1926) described two kinds of amitotic divisions: one, the result of a dumb-bell-like division; the other, the formation of a partition which cuts the nucleus in two parts. Other writers who have suggested amitosis include Auer-

bach (1911) in *Henneguya psorospermica*, Mavor (1916) in *Ceratomyxa acadiensis*, Bremer (1922b) in *Myxidium lieberkühni*, Davis (1923) in vegetative cells of *Lentospora ovalis*, Debaisieux (1925) in *Myxobolus notatus*, and Naville (1930) in several genera of Myxosporidia.

Amitosis possibly occurs in the Myxosporidia during the rapid multiplication of vegetative nuclei following the fusion of sporoplasm gametes. These nuclei are generally smaller than succeeding nuclei, and in those species which develop large multinucleate plasmodia or cysts they form a syncytial body. As development progresses, some of these small nuclei enlarge and become surrounded by delimited cytoplasm, thus becoming cells. The latter divide by mitosis.

Cytological differentiation between generative and vegetative nuclei is often marked. Vegetative nuclei may be smaller or larger than generative nuclei, and they usually do not have the characteristic pattern of large karyosome and peripheral chromatin. The two types of nuclei may both be derived from vegetative nuclei. It is the vegetative nucleus which appears to divide by amitosis. In some species, the generative nuclei lie in a vacuole (after fixation with Zenker's, Bouin's and Schaudinn's fluids) and are often surrounded by by their own specialized cytoplasm.

THE GROWTH PHASE

The myxosporidian life cycle begins with the zygote after sporulation. Although the two haploid sporoplasm nuclei have been reported to fuse before sporulation, probably this fusion, or fertilization, more commonly occurs during the migration of the parasite from the digestive tract of the new host to its site of final infection. In monosporous and disporous species, the diploid zygote usually begins a series of cell divisions and growth accompanied by budding. In the large polysporous species, a process of nucleogony and cytoplasmic growth follows fertilization. The earliest stages of most species are syncytial. During early growth of the parasite the two types of nuclei described above can be distinguished: *vegetative* nuclei are responsible, by their active division, for multiplication of the numbers of the parasite, whereas *generative* nuclei are destined to produce spores.

Bremer (1922a) described simple plasmotomy, multiple plasmotomy and endogenous budding in *Myxidium lieberkühni*. Laveran and Mesnil (1902) concluded that endogenous multiplication occurs by means of the equal or unequal plasmotomy of very young forms. Both endogenous and exogenous budding have frequently been reported (Noble, 1941; Kudo, 1922). The buds may repeat the cycle or they may begin spore formation. The cytoplasm tends to become differentiated about some of the nuclei, forming separate cells within the trophozoite. Schröder (1907), Lo Giudice (1912), and Georgévitch (1919) described the formation of a generative cell from vegetative nucleus by a condensation of cytoplasm around the nucleus. Noble (1943), however, has demonstrated distinct "cells" as part of the vegetative phase of *Myxidium gasterostei*. Trinucleate trophozoites are often seen to be more numerous than other stages (see Kudo, 1922, on *Leptotheca*; Noble, 1941, on *Ceratomyxa*). The trinucleate trophozoite is usually considered to be a propagative cell.

The most recent accounts of the growth phase have described all its divisions as diploid, but some of the earlier writers found figures which they took to indicate that gamete formation and fertilization regularly occur before sporogony. Awerinzew (1908, 1909, 1911, 1925) described the production, soon after the zygote, of a binucleate amoeba, followed by a 4-nucleate state. Two of these nuclei are trophic and two are generative. The two generative nuclei divide reductionally into macrogametes and microgametes. These gametes fuse to form a synkaryon, which begins the sporogony phase of the life cycle. Naville (1930) has been the foremost proponent of the view that there are two periods of gamete formation and two zygotes during the life history of a myxosporidian parasite. Such a cycle results in a double alternation of diploidy and haploidy. Naville has listed the works of numerous authors as supporting his views. Because generally in the Myxosporidia there are seldom clear figures of both centrioles and spindle fibers it is difficult to distinguish between a metaphase or late prophase which shows four diploid chromosomes and an early anaphase after reduction which also shows four chromosomes (two sets of haploids). Naville claims that Georgévitch (1919) figured a mainly haploid cycle for *Myxidium gadi*, but Georgévitch (1935, 1936) points out that his description of this species did not include a gamete formation before sporogony, and that the cycle is mainly diploid. "Schizogony" is terminated, according to Naville, by a premeiotic period.

A typical example of the mainly haploid cycle is that of *Chloromyxum leydigi*, described by Naville in 1927. The cycle starts with the liberated

diploid sporoplasm, which divides rapidly by diploid mitosis, showing four chromosomes. During this multiplicative growth phase many external uninucleate buds and internal polynucleate buds are formed. The latter budding is accompanied by the degeneration and elimination of parts of the larger nuclei. A more advanced stage shows a number of haploid, heteropolar divisions resulting in anisogamy. Each of these nuclei becomes surrounded by an area of hyaline cytoplasm, and fertilization then takes place. A reduction division occurs immediately after zygote formation, and the following bulk, of the cycle, concerned with spore formation, is haploid. Georgévitch (1917) has described complex methods of propagation and budding during the growth phase of the disporous species *Ceratomyxa herouardi*. He believed that autoinfection of the host occurs by new spores formed in the trophozoite as well as by division of the multinuclear trophozoites.

THE SPOROBLAST

After a short, asexual, multiplicative phase, or a period of nucleogony, certain nuclei begin spore formation. The original cell which starts sporogony is known as the initial stage of the sporoblast. The method by which this stage is formed is one of the most interesting and important points under dispute by various investigators of the Myxosporidia. It is here that much of the discussion pertaining to sexualization is centered. If the sporont (sporoblast) produces two or more spores it is called a "pansporoblast."

Even a cursory survey of the literature reveals that several strikingly different types of cycles have been described. The reason for these differences probably lies in the interpretations of stained material, rather than in any essential differences in the stages of the various life cycles. The minuteness of the parasites has made it impossible to observe accurately the different stages of development in living material, so observations must be made upon killed and stained preparations. This limitation obviously necessitates sorting out and piecing together large numbers of static figures to express what is actually a dynamic process of continuous development.

Until the time when tissue culture techniques can be used with the Myxosporidia, or until other methods of observing the actual divisions of individual cells are introduced, the safest approach to the problem will be to find the simplest explanation which accounts for all observed phenomena, and to eliminate the more complex interpretations. Such a course of procedure has already been proposed by Davis (1923).

The various described methods of pansporoblast formation can be grouped under three headings: 1, by the fusion of two nuclei; 2, by plasmogamy (the fusion of the cytoplasm of two or more cells); 3, by the differentiation and growth of a single cell without previous union of nuclei or cytoplasm.

1. Awerinzew (1908, 1909) described the formation of a synkaryon before spore development in *Ceratomyxa drepanopsettae*. In this species a young binucleate trophozoite with identical nuclei gives rise to a stage in which there are four nuclei, of which two are trophic in function and the other two give rise, by division, to macrogametes and microgametes. A reduction division follows by the extrusion of a chromatic granule from each gamete, and each macrogamete unites with a microgamete. In this particular case a double fertilization is said to occur, resulting in two zygotes which become the basis of a disporous pansporoblast. Erdmann (1917b) pointed out that the figures of Awerinzew could easily be arranged so as to represent the division of gametocytes into two cells, the smaller of which forms the membrane of the pansporoblast.

Mercier (1909) described the copulation of gametes before sporulation of *Myxobolus pfeifferi*. Some of the early stages divide to form macrogametes and microgametes, and fertilization occurs. His figures of chromosome behavior, however, are not clear. Parisi (1913) and Southwell and Prashad (1918) described a copulation of gametes before sporogony to produce a zygote which becomes the initial form of the pansporoblast.

A typical life cycle as interpreted by Naville (1928, 1930) may be illustrated with *Myxobolus guyénoti* (fig. 4). The diploid zygote gives rise to a large number of diploid "schizonts" which represent the multiplicative stage. Some of the latter divide to form macro- and microgametes which are produced by a reduction division, the chromosome number being reduced from 4 to 2. A macrogamete and a microgamete fuse to form a diploid zygote which is the pansporoblast. The diploid condition, however, does not last long, as will be seen below in the discussion of sporogenesis. There exist two fertilizations and two zygotes in the life cycle, because gametes are again formed at the end of sporogony. The same author described a more elaborate condition in *Sphaeromyxa sabrazesi* (fig. 5) as follows: At the end of the diploid growth period a diploid, vegetative nucleus becomes sur-

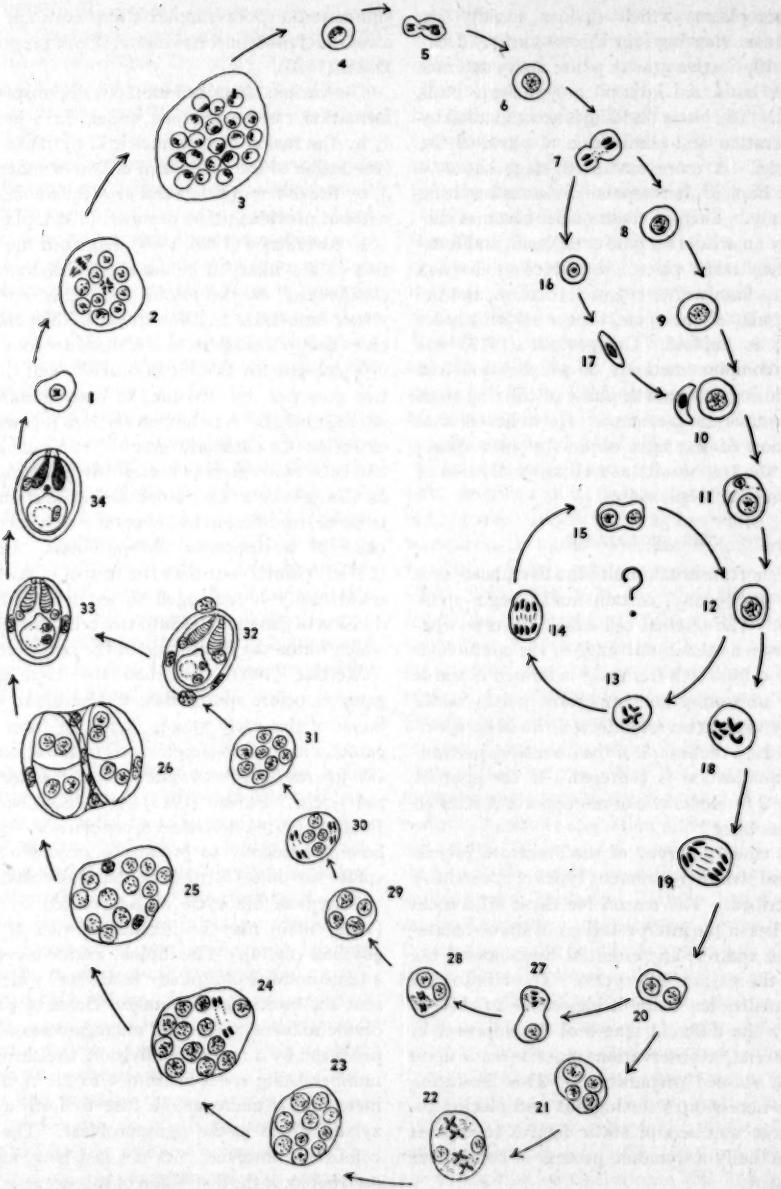

FIG. 4. LIFE CYCLE OF MYXOBOLUS GUYÉNOTI

1–2, schizogony; 3–4, premeiosis; 5–7 chromatic reduction; 8–9 and 16–17, gametogenesis; 10–12, fertilization; 13–15, probable cycle of the multiplication of the zygote; 18–20, formation of sporont; 20–26, disporous sporogenesis; 27–32, monosporous sporogenesis; 33, spore with binucleate sporoplasm (dihaploid phase); 34, spore with synkaryon in sporoplasm.

(After Naville, 1928, in Z. Zellforsch.)

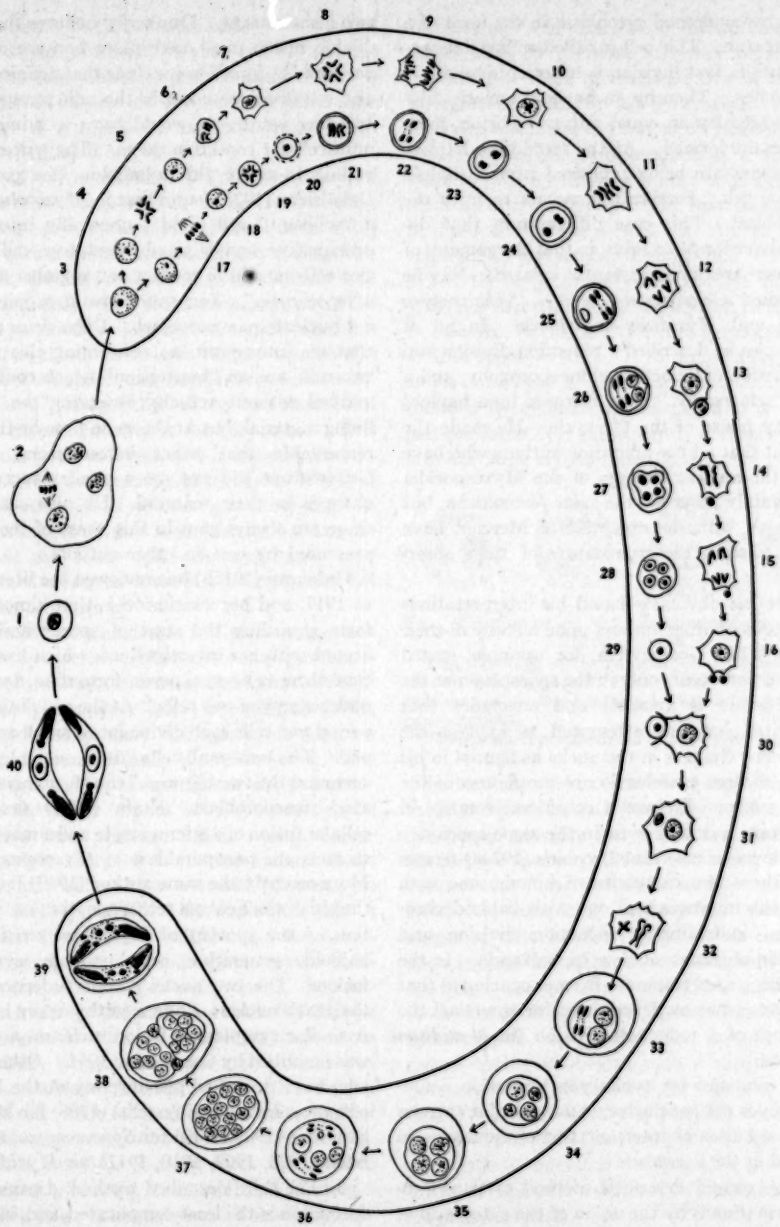

FIG. 5. LIFE CYCLE OF SPHAEROMYXA SABRAZESI

1, diploid, uninucleate sporoplasm; 2, schizogony and cytoplasmic growth; 3–5, 17–18, diploid schizogony; 6-16 and 19–29, gametogenesis; 11–12 and 22–23, reduction divisions; 29, microgamete; 16, macrogamete; 30, fertilization; 31, diploid synkaryon at the start of sporogony; 30–39, sporogony; 40, mature spores.
(After Naville, 1930, in Arch. Protistenk.)

rounded by condensed cytoplasm in the form of a polygonal star. This cell is called a "macrogonacyte," and its first division is mitotic, involving 4 chromosomes. Then by an unequal meiotic division, followed by an equal mitotic division, macrogametes are formed. At the same time haploid microgametes are being produced from a diploid vegetative cell. Fertilization occurs to form the pansporoblast. This case differs from that described above for *Myxobolus*, in that the gametes of the former are more distantly related. Naville also studied *Chloromyxum leydigi*, *Sphaeromyxa balbianii* and *Myxidium incurvatum*. In all of these species he described a reduction division and the formation of gametes before sporogony, and a diploid "schizogony" phase followed by a haploid sporogony phase of the life cycle. He made the statement that all the preceding authors who have studied the nuclear changes of the Myxosporidia have certainly observed the same phenomena, but all of them, with the exception of Mercier, have failed to discern the true nature of their observations.

Naville has obviously based his interpretations of the works of other authors upon a study of their figures. When Georgévitch, for example, stated that reduction occurs only in the sporoplasm of the spore, Naville is amazed, and concludes that Georgévitch has not attempted to explain the chromosome changes in the nuclei as figured in his plates. A close examination of the figures of the various authors discloses a considerable range in chromosome numbers even in the same species.

Naville has stated that Bremer's (1922a) figures clearly show two categories of kinesis, one with diploid chromosomes and one with haploid chromosomes, indicating a reduction division and copulation of gametes before sporogenesis. In the text of his paper, however, Bremer concluded that he can present no evidence either for or against the occurrence of a reduction division (in *Myxidium liebeskühni*).

Thus evidence for synkaryon formation before sporogony is not conclusive, and much of it appears to be based upon an interpretation of the figures to be found in the literature.

2. The second described method of pansporoblast formation is by the union of the cytoplasm of two cells without nuclear fusion. This type of union is called "plasmogamy." Dunkerley (1915, 1925) has described the formation of the pansporoblast of *Agarella gracilis* by the production of "microcytes" and "megalocytes." In this process two fusions occur. Dunkerley believes that such a double fusion must take place because otherwise we would be forced to conclude that definite nuclear and cell divisions occur in the unit pansporoblast. In other words, we would have to admit that a multicellular condition exists. The writer is quite willing to make this admission (see page 233). Debaisieux (1925) found that in *Myxobolus notatus* a "schizont" cell divides unequally into a large propagative and a small vegetative cell. These two cells remain in contact and together are called a "sporocyte." Two sporocytes then join to form a 4-nucleate pansporoblast. Debaisieux admitted that his interpretations concerning this union of two cells was an "impression" which could not be verified without actually observing the union in living material, but at the same time he thought it remarkable that other investigators, such as Georgévitch, did not see a similar succession of changes in their material. He also stated that there are always gaps in this phase of the cycle as presented by certain other authors.

Erdmann (1917b) has reviewed the literature up to 1917, and her conclusion is that almost all the facts regarding the start of sporogenesis are in accord with her investigations, which have shown that there is no synkaryon formation, but merely plasmogamy of two cells. At the end of the growth period two cells each divide into a small and a large one. The two small cells "draw out in length and surround the two big ones," thus forming a 4-nucleated pansporoblast. Kudo (1917) described a cellular fusion of a microgamete and a macrogamete to form the pansporoblast of *Myxobolus toyamai*. More recently the same author (1943) found, with the aid of the Feulgen technique, that in the formation of the sporont of *Myxidium serotinum* two haploid, generative cells undergo cytoplasmic fusion. The two nuclei remain independent and thus each nucleus of the resulting spore is haploid. A similar cytoplasmic fusion in *Henneguya otolithi* was described by Ganapati in 1941. Other authors who have described plasmogamy at the beginning of sporogenesis are Keysselitz (1908) for *Myxobolus*, Schröder (1907, 1910) for *Sphaeromyxa*, and Auerbach (1908, 1909, 1910, 1912) for *Myxidium*.

3. The third described method of pansporoblast formation is the least complicated, and, in the opinion of the writer, is supported by the most evidence. This interpretation involves no union of either nuclei or cells. At the end of the early multiplicative, or growth, phase certain cells become differentiated, either by enlargement or by cytoplasmic

condensation. Each of these cells is the initial form of a pansporoblast, or the start of a single spore if no pansporoblast is produced. There is thus no sexual process before sporogony other than the union of gametes in the sporoplasm which begins the entire life cycle.

Davis (1916) emphasized that in *Sphaerospora dimorpha* the pansporoblast is derived directly from a single propagative cell. Later Davis (1923) working with *Lentospora*, found that certain generative cells divided by a heteropolar mitosis into two unequal cells which did not separate, as all the previous generative daughter cells had done, but remained so closely in contact that he was usually unable to distinguish any line of demarcation between them. The smaller of the two nuclei had irregular chromatin without the karyosome. This stage is the pansporoblast, and it appears remarkably similar to the description by Noble (1943) of the same stage in *Myxidium gasterostei* (fig. 6). Davis has suggested that both Mercier (synkaryon formation) and Kudo (plasmogamy) have "read the course of events backwards and interpreted cell division as cell fusion."

In 1916 Mavor found that in *Ceratomyxa acadiensis* each sporoblast originates from a sporoblast-mother-cell, which in turn is formed by the division of a single propagative cell. Georgévitch (1917, 1919) corroborated these findings in his work on *Ceratomyxa herouardi* and *Myxidium gadi*. The sporoblasts in the former species and the pansporoblasts in the latter species develop from certain propagative cells without fusion. Even before these findings, Georgévitch (1916b) warned of the danger of concluding that a sexual phenomenon occurs before sporogony. He explained that a fertilization at this point would mean the occurrence of two isogamic or anisogamic sexual processes in the same evolutionary cycle. Schuurmans-Stekhoven (1920) also demonstrated that in *Myxobolus destruens* the 4-celled initial stage of the pansporoblast is not formed through a copulation of two gametoblasts, but results from the division of a single cell. The formation of a similar 4-celled stage in *Henneguya gigantea* has been described by Georgévitch (1914) as follows: Each single-celled pansporoblast gives off a small bud, thus forming a stage of two cells of unequal size. These binuclear forms are the gametoblasts. From this stage a characteristic 4-celled sporoblast is formed by the division of each of the original two cells.

In 1922 Kudo described the development of characteristic trinucleate stages at the end of "schizogony" in *Leptotheca ohlmacheri*. These stages arise by division, and they represent the beginning of spore formation. One of the nuclei is vegetative and two are generative. A similar situation was found in *Ceratomyxa blennius* (Noble, 1941), where the pansporoblast is a trinucleate stage formed by division from a single generative nucleus, or by budding. The first pansporoblast in this species is the zygote (fig. 1). In a related species (*C. herouardi*), Georgévitch (1917) also called the zygote the pansporoblast because it gives rise to a trinucleate stage which in turn, as in *C. blennius*, develops either into generative stages or into spores. Kudo (1926) found that in *Myxosoma catostomi* a single nucleus becomes surrounded by cytoplasm, enlarges, and is then the pansporoblast. It subsequently divides by mitosis into one large and one small cell.

FIG. 6. DIVISION OF THE PANSPOROBLAST TO FORM FOUR CELLS

1, initial stage of the pansporoblast formed by division from a single cell; 2, anaphase; 3, the daughter cells remain in close contact; 4, four-celled stage of the pansporoblast.
(From stained preparations of *Myxidium gasterostei*)

In 1935 Georgévitch reviewed the literature on the Myxosporidia, with particular emphasis on the question of sexuality and general nuclear behavior. He made a special point of contrasting his observations with those of Naville, and he rejected the latter as completely unfounded. Georgévitch suggested that Naville has based his conclusions upon supposition rather than upon positive investigation. Georgévitch (1935, 1936) reviewed his own research on *Myxidium*, *Henneguya*, *Myxobolus*, *Sphaeromyxa*, and *Zschokkela*. In all of these genera sporogony begins with a diploid sporont (pansporoblast) without cellular fusion or fertilization. Noble (1941, 1943), working with *Ceratomyxa blennius* and *Myxidium gasterostei*, is in agreement with Georgévitch and the other authors who find no evidence for a union of separate cells to form the pansporoblast.

SPORE FORMATION

Of all phases in the life cycles of the Myxosporidia the problem of spore formation has occupied the most attention of investigators. Perhaps the

reason for this attention is because spore structures are more attractive and are easy to identify. Many writers have reported detailed findings on spore development. Among the first of these authors were Bütschli (1881), Balbiani (1884), Thélohan (1895), and Doflein (1898).

The Myxosporidia are monosporous, disporous, or polysporous, and all three phenomena may occur in one species. The general pattern of the cellular changes which occur in sporogony is the same for all species, but the number of cells involved varies according to the number of spores which are produced at one time, and with the number of residual nuclei. Some significant differences in the point at which reduction of chromosomes takes place have been described. These differences will be discussed below.

By cytoplasmic growth and a series of mitotic divisions a sporoblast of 6 or 8, or a pansporoblast of 14 nuclei (sometimes 16 or 18 depending on the number of capsules in a spore) is formed. In the latter group, a division into two sporoblasts then occurs, each sporoblast usually consisting of 6 generative nuclei, with 2 somatic residual nuclei which disintegrate. The somatic residual nuclei have been called the functionless nuclei of the sporont membrane cells. Davis (1923) asks, "Is it not possible that the formation of envelope cells may be a device developed by the polysporous forms to insure the proper segregation of the cells to form the spores?" The term "residual nuclei" came from the suggestion of some investigators (Keysselitz) that envelope cells represent reduction nuclei.

Of the 6 nuclei in a sporoblast two are shell valve nuclei, and they become surrounded by their own distinct cytoplasm, which then begins to surround the sporoblast. Each sporoblast is enveloped by two shell valves. The valve nuclei quickly become hypertrophied, flattened, and thin-walled. Their chromatic substance is gradually adsorbed by the spore cytoplasm. These nuclei are the first of the spore nuclei to disappear. They are last seen on the inside of the spore walls. Whether the valves are produced entirely by the cytoplasm or in part by the valve nuclei has not been determined.

In 1921, Kudo found that the spore membrane of *Henneguya salminicola* (taken as a representative of the Myxosporidia) proved to be composed of a substance whose chemical reactions are less similar to those of chitin than the spore membrane of the microsporidian *Nosema*. More recently, Bond (1937) tested spore valves with Mallory's triple stain and the Feulgen nuclear reaction, and the results indicated the presence of thymonucleic acids without polysaccharides. Valves may be smooth (*Ceratomyxa*) or they may be provided with conspicuous ridges forming a distinct pattern (*Myxidium*). The suture line may be raised.

Two other nuclei of the sporoblast give rise to polar capsules. These nuclei also become surrounded by distinct delimited cytoplasm, and thus are cells. Each polar capsule is first seen to develop in the cytoplasm of the cell. In unstained material this anlage of the polar capsule appears as a vacuole filled with small refractile granules. In stained material (iron hematoxylin) it appears as a light gray sphere with faint, small granules. The capsule nucleus remains intact in its size and staining reactions until the polar capsule is completed; then it tends to disappear. This persistence indicates that the nucleus does not itself become part of the membrane.

Thélohan (1890) stated that the polar capsules are formed at the expense of small masses of plasma (cells) that become differentiated in the sporoblasts and each contain a nucleus. Mavor (1916) observed that polar capsules form in their own cells, and he suggested that polar filaments, like the valves of the spore envelope, are formed from metamorphosed protoplasm. Kudo (1921) disagreed with Erdmann's (1917b) conclusion that the polar filaments are composed of glycogen. Kudo believes that they are formed by the mixture of a part of the nucleus and a substance differentiated in the capsulogenous cell. Polar filaments develop as coiled threads within capsules. These threads may be induced to discharge if treated with various reagents (concentrated KOH, dilute mineral acids, ether, gastrin, glycerine, etc.).

The remaining two sporoblast nuclei become the sporoplasm or ameboid nuclei. They are the gametes which unite, usually after sporulation. These nuclei normally take on the typical pattern of myxosporidian nuclei, each with a large eccentric karyosome and conspicuous, crescentic, peripheral chromatin. They usually lie close together in the center of the sporoplasm. The sporoplasm may occupy all of both valves or it may be withdrawn from the valve ends, or it may be restricted to one valve. Kudo (1921) stated that the iodinophilous vacuole of the spores of the family Myxobolidae contain a substance with a glycogen-like chemical reaction. All spore structures, with the exception

of the sporoplasm and its nuclei, are temporary expedients to protect and assist the infective germ as it passes from one host to another.

In the following discussion emphasis is made on deviations from the general pattern outlined above.

Noble (1941) has reviewed the life histories of six species of the genus *Ceratomyxa*. Detailed account was given *C. blennius*, where spore formation begins with a trinucleate trophozoite (fig. 1, *4*). Of the three nuclei in the pansporoblast one is vegetative and two are generative. The vegetative nucleus remains undivided, and takes no part in spore formation. The generative nuclei divide to produce two generative and two valve nuclei (*5*), and the latter each divide to form the four valve nuclei of the pansporoblast. The two generative nuclei also divide (*8*). At this point there are nine nuclei: one vegetative, four valvular, and four generative. The two sporoblasts may now appear (*8*) by the exclusion of the vegetative nucleus and the segregation of two of each of the other nuclear types into delimited cytoplasmic bodies. One generative nucleus now divides to form the two polar capsule nuclei, while the last generative nucleus undergoes a reduction division, and two gametic, haploid nuclei result (*8*). The two valve cells of each sporoblast surround the other cells, forming a bivalved protective coating which gradually assumes the characteristics of the thin, transparent spore membrane (*9*). The valve nuclei are usually seen at opposite ends of the spore. The cytoplasm about the capsular nuclei condenses to form capsular cells. Beside the nucleus of each of these cells a polar capsule develops. The polar capsule first appears as a faint ring close to the capsular nucleus (*9*). The latter, with the cell membrane, gradually degenerates until hardly discernible in mature, stained spores. The sporoplasm nuclei assume the typical resting appearance, and they remain side by side, the karyosomes turned away from each other (*11*).

According to Georgévitch (1929), sporulation of *Ceratomyxa menae* begins with a uninucleate sporont which is distinguished from a uninucleate generative cell by its larger size and by its tendency to develop multinucleate trophozoites with two to many sporoblasts. Sporoblasts are endogenous buds, and there are two vegetative nuclei.

Naville (1927) has described the complete life cycle of *Chloromyxum leydigi*. In this species formation of the spore begins with a heteropolar division of a diploid nucleus. This division is said to be reductional and is followed by the formation of a group of four haploid nuclei—two large and two small. The two large ones divide, and the resulting daughters also divide to form eight nuclei. The first two small nuclei degenerate. Each spore is formed from two shell valve cells, four capsular cells, and two sporoplasm nuclei. According to Naville's interpretation, all of these nuclei are haploid.

In *Henneguya gigantea*, Georgévitch (1914) found that the nucleus of the pansporoblast divides unequally. From this stage a characteristic four-celled sporocyst is developed by the division of each of the original cells. By a series of nuclear mitotic divisions and by cytoplasmic growth the larger two nuclei give rise to two spores, while the smaller two degenerate (fig. 7).

In *Lentospora ovalis*, Davis (1923) has found that the vegetative nuclei are larger and they stain less intensely than the generative nuclei. Vegetative nuclei take no part in spore formation. The generative nucleus divides to produce a small nucleus which gives rise to envelope cells and a larger nucleus with a karyosome which gives rise to the other spore structures.

Kudo (1922) has also described, in *Leptotheca ohlmacheri*, the formation of a tri-nucleate body which begins sporogony. Each spore in this species contains two separate sporoplasms, one for each valve. A similar condition was observed by Thélohan (1895) in the spore of *Ceratomyxa sphaerulosa*. In this species, however, each sporoplasm contains only one nucleus.

In 1910 and 1912 Auerbach outlined the life cycle of *Myxidium bergense* (fig. 8). He described a synkaryon at the start of spore formation, and a synkaryon in the ripe spore. Bremer (1922a) found that in *M. lieberkühni* some of the enlarged, early, generative cells begin the diploid sporogony phase of the life cycle. Georgévitch (1919) has made a detailed study of the cycle of *M. gadi*. Here a single, enlarged cell begins spore formation. The nucleus of this cell divides to produce a large germinative and a small vegetative nucleus. The latter divides once to form two small trophic nuclei which soon degenerate. From the germinative nuclei there arise, by mitotic divisions, six spore-forming nuclei or cells. Noble (1943) has more recently described the life cycle of *M. gasterostei*. Here the cycle (fig. 2) is essentially similar to that described by Georgévitch. The principal differ-

ence between the two lies in the method of chromosome reduction at the end of sporogony.

Mercier (1906, 1919) has described sporogony beginning with a zygote in *Myxobolus pfeifferi*. After cytoplasmic growth and a series of nuclear divisions the sporont contains 14 nuclei. These nuclei divide evenly to form the two sporoblasts. The two small vegetative nuclei are excluded. Keysselitz (1908) described the formation of the spore of *M. pfeifferi* from a binucleate pansporoblast. Later a 12-celled stage is developed, and the two gamete cells of each side fuse without union of their nuclei. Then the ten cells become divided into two sporoblasts. In *M. swellengrebeli* the process of spore construction is purely vegetative according to Schuurmans-Stekhoven (1919), and we must consider the spore as a cyst endogenously formed.

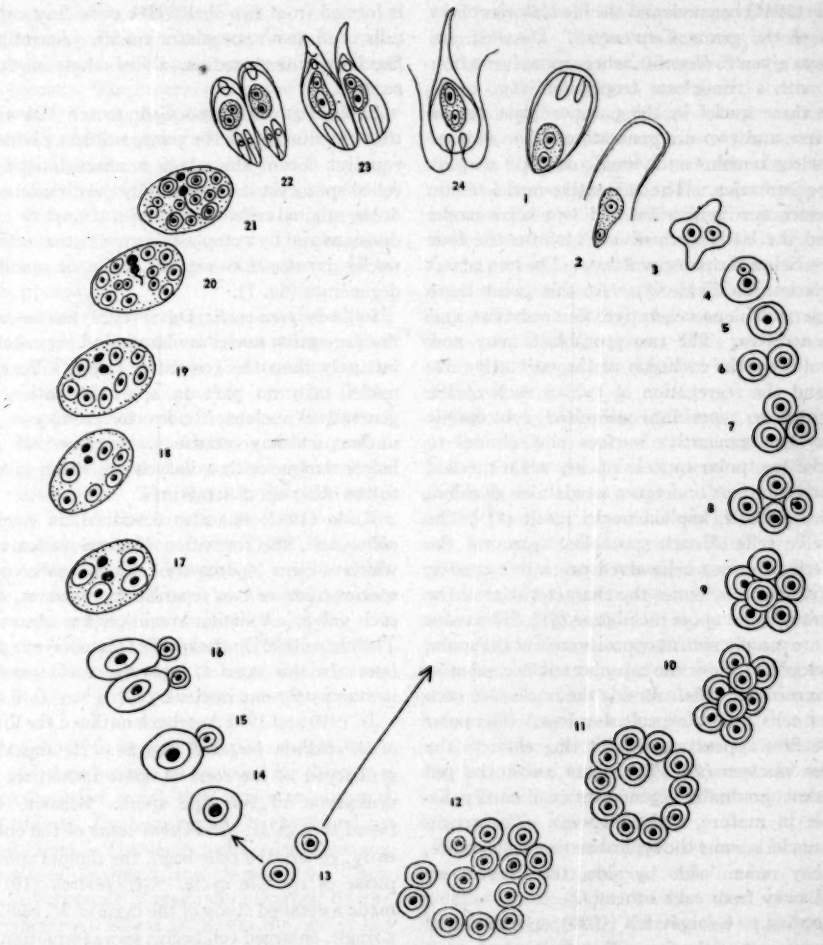

FIG. 7. LIFE CYCLE OF HENNEGUYA GIGANTEA

1–2, germination of the spore; 3, binucleate ameboid stage; 4, rounded binucleate stage; 5, pansporoblast; 6–13, schizogony; 14, pansporoblast ready to bud; 15, gametoblast; 16, sporocyst; 17–20, sporulation; 20–21, two sporoblasts in sporocyst beginning spore formation; 22–23, spore formation; 24, mature spore.
(After Georgévitch, 1914, in Arch. Zool. exp.)

The life cycle of *Myxobolus guyénoti* has been worked out by Naville in 1928 (fig. 4). According to this author a zygote begins spore formation, and the first or second division after the zygote is a reduction division. Sporogony is thus haploid. In the disporous pansporoblasts, as well as in the monosporous pansporoblasts, there are two vegetative nuclei which take no part in spore formation. according to Schröder (1907), is a single cell with four nuclei—two large and two small. After a series of mitotic divisions, 14 nuclei are formed and the plasma divides into two sporoblasts which become ellipsoidal. Each of the shell valve nuclei becomes surrounded by a distinct plasma layer, and each envelopes a half of a sporoblast. The first anlage of the pole capsule is a small, faintly

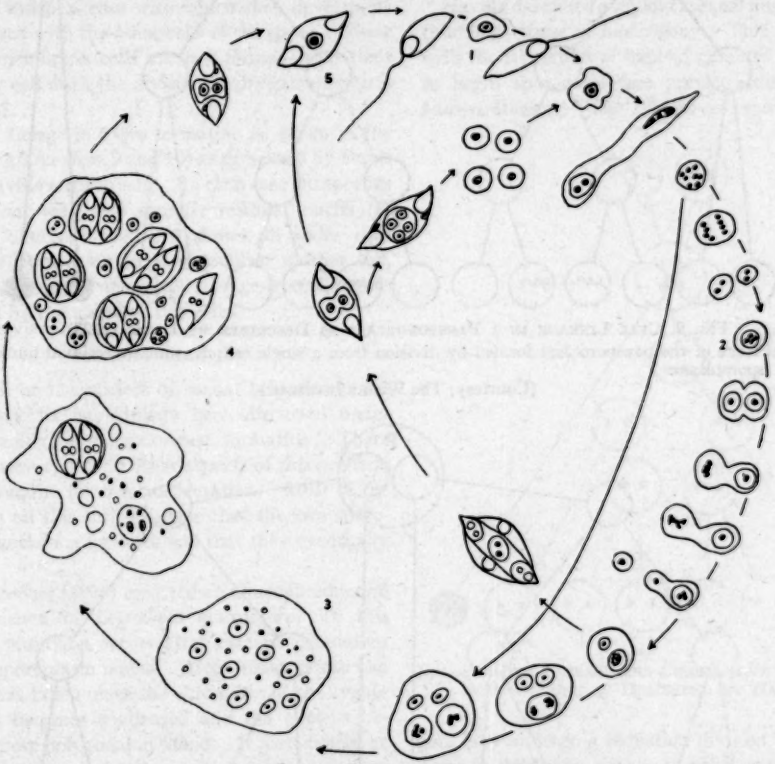

FIG. 8. LIFE CYCLE OF MYXIDIUM BERGENSE

1, infective amebula stage after sporulation; 2, synkaryon formation at the start of sporogony; 3, young plasmodium with numerous pansporoblasts; 4, older plasmodium with young spores; 5, mature spore with synkaryon in sporoplasm.

(After Auerbach, 1910, and 1912 in Zool. Anz.)

Very little work has been done on life cycles in the genus *Myxosoma*. Kudo (1923, 1926) found that in *M. catostomi* the uninucleate pansporoblast undergoes a heteropolar division. The smaller cell divides to produce the usual two inactive vegetative nuclei. The larger product of the initial stage of the pansporoblast is the generative cell which gives rise to the spore or spores.

In *Sphaeromyxa sabrazesi* the pansporoblast, stainable spindle which is enclosed by a vacuole. There are, as usual, two residual nuclei. Schröder believed that the spore cases are probably not formed from the disintegration of the shell valve nuclei.

In the case of *Zschokkella rovignensis*, sporogony is mono-, di-, or polysporous. Sporogony begins with a diploid uninucleate sporont. In the polysporous plasmodium the spores are found in

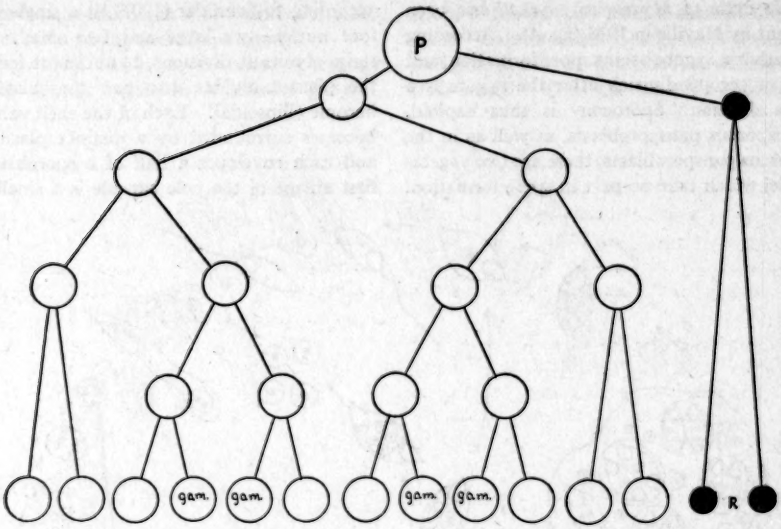

FIG. 9. CELL LINEAGE IN A PANSPOROBLAST AS DESCRIBED BY DAVIS (1923)
P, initial stage of the pansporoblast formed by division from a single cell; R, somatic residual nuclei; gam., gamete in sporoplasm.
(Courtesy, The Wistar Institute.)

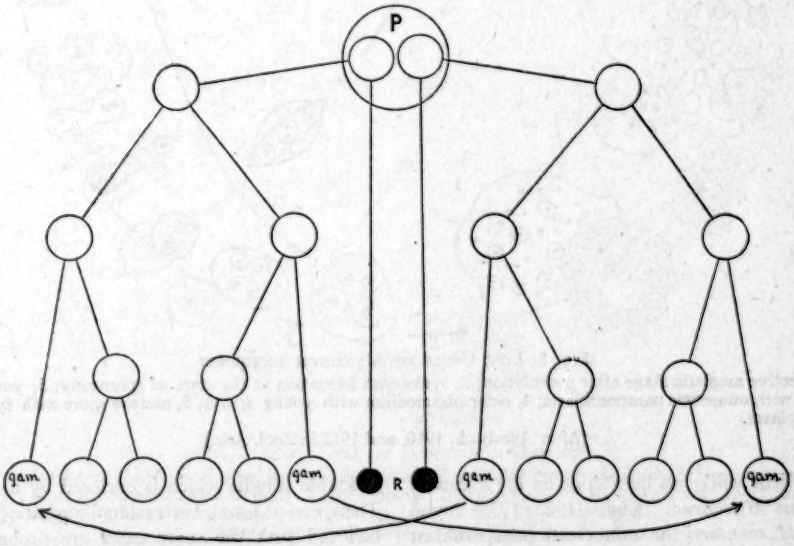

FIG. 10. CELL LINEAGE IN A PANSPOROBLAST AS DESCRIBED BY NAVILLE
P, initial stage of the pansporoblast formed by the union of two cells; R, somatic residual nuclei; gam., gamete in sporoplasm of each spore.

the so called "islands" from which mature spores easily fall out (Georgévitch, 1936).

Cell lineage in spore formation is difficult to trace with accuracy. Erdmann (1917a) has pointed out

that in *Chloromyxum leydigi* the two spore-membrane-forming cells are developed from two gametocytes (sporont cells), whereas in *Myxidium* sp., *Ceratomyxa drepanopsettae*, and *Sphaerospora dimorpha* a single gametocyte forms one cell which divides to produce the two valve cells. Erdmann found that the cells which form the spore membrane have a similar origin and are distinguished by the independence with which they develop, as compared with the other cells of the spore. These spore membrane cells are not formed from their mother cell until the division of the gametocyte is finished.

Cell lineage in spore formation is shown in the two diagrams (figs. 9 and 10) as presented by Davis and Naville respectively. In each case a disporous condition, with two somatic residual nuclei (in black) obtains. Figure 9 shows all spore cells derived from a single pansporoblast mother cell, whereas figure 10 shows cell lineage from a zygote formed by the union of two cells.

SEXUAL BEHAVIOR

Much of the subject of sexual behavior in the Myxosporidia has already been discussed under the heading of pansporoblast formation. There are, however, certain other aspects of this problem which require further consideration. Most of the authors on this subject agree that the two sporoplasm nuclei are gametes and that they eventually fuse.

Kalenscher (1926) reported an unusual reduction phenomenon in *Leptotheca macrospora*. In this species reduction occurs after gametic copulation of the sporoplasm nuclei. After fusion of the two nuclei has taken place the chromatin of the zygote nucleus becomes condensed and the nucleus becomes more polygonal in shape. It then expels, at one edge, two compact, spherical chromosomes which migrate to the cell membrane and finally disappear. Shortly afterwards, two other reduction chromosomes are expelled and are also absorbed in the cytoplasm. Each of the original gamete nuclei has four chromosomes. Thus the eight chromosomes of the zygote are reduced to four. This haploid cycle, where the zygote is the only diploid stage, is suggestive of some of the Telosporidia (see Noble, 1938, on *Zygosoma globosum*). The accuracy of the above interpretation, however, is questionable.

Gametes of *Myxidium gadi* are haploid, whereas gamete nuclei of *Leptotheca macrospora* (according to Kalenscher) are diploid. Bremer (1922a) could find no evidence either for or against the occurrence of a reduction division in *Myxidium*. Nemeczek (1922) could not determine the position of the reduction division in *Zschokkella rovignensis*, but he believed that the cycle in this species is haploid. This view was vigorously contradicted by Georgévitch (see below).

Naville described a diploid asexual multiplicative (budding) phase or nucleogony. This phase ends with the formation of haploid gametes which fuse to begin sporogony (see previous discussion of pansporoblasts). The diploid pansporoblast zygote may undergo a reduction division, but sometimes it divides by mitosis to produce two diploid nuclei. One of these nuclei then divides by meiosis, and the other persists as the diploid, somatic residual nucleus. There are thus three nuclei, one of which is diploid and two haploid. The diploid nucleus may divide by mitosis to give two residual nuclei, while the haploid nuclei further divide to continue spore formation (fig. 11). Naville calls this type of sporogony the "diphaploid phase." Obviously, there is no need for a further reduction to make the sporoplasm nuclei haploid. The sporoplasm nuclei then fuse to restore the diploid number of chromosomes either before or immediately after sporulation. Such a cycle has been

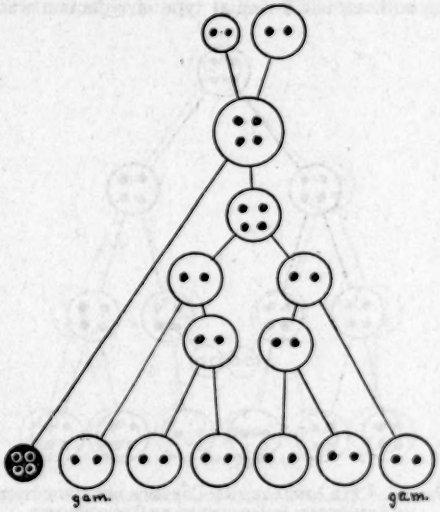

FIG. 11. CELL LINEAGE AND CHROMOSOME REDUCTION IN SPOROGONY AS DESCRIBED BY NAVILLE

described by Naville for *Sphaeromyxa sabrazesi*, *S. balbianii*, *Chloromyxum leydigi*, *Myxobolus guyénoti* and *Myxidium incurvatum*. Naville's supposition that almost all other authors have failed to discern the true nature of their observations is not well founded.

Different methods of reduction have been described for the Myxosporidia. Awerinzew (1909) found that in *Ceratomyxa drepanopsettae* two generative nuclei divide into macrogametes and microgametes. Reduction in chromatin of these gametes is accomplished by the extrusion of chromatic granules from each. Much doubt regarding this cycle has been shown in the writings of succeeding authors, but a similar type of reduction was

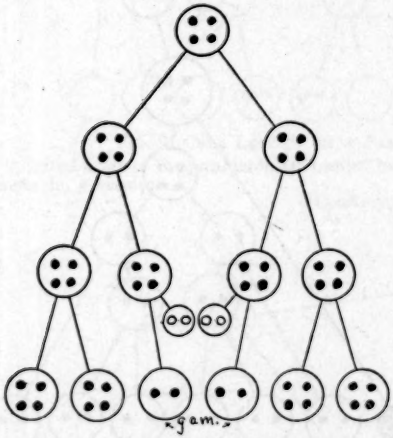

FIG. 12. CELL LINEAGE AND CHROMOSOME REDUCTION IN SPOROGONY AS DESCRIBED BY GEORGÉVITCH

described by Georgévitch in several papers. The latter author believes that reduction in the Myxosporidia occurs by the casting off of small bodies from each sporoplasm nucleus (fig. 12). Erdmann (1917b) criticized these findings, and she believed that all such "reduction nuclei" are glycogen bodies which are used up in the formation of spore structures. Davis (1923) agreed that there is no evidence for a nuclear origin of the bodies, but he called them "chromatoid bodies." As was pointed out by the writer (1943), the presence of small, deeply staining bodies in the cytoplasm of the Myxosporidia at all stages is of common occurrence, and unless actual chromosomes are observed, the establishment of the location of a reduction division must remain in doubt.

A typical example of differences of opinion on the question of sexuality is that concerning *Zschokkella rovignensis*. According to Nemeczk (1922), the cycle of this species is almost entirely haploid. The chromosome number in the generative cells is four and there is no reduction division before synkaryon formation. He could not determine the exact position of reduction. Georgévitch (1935, 1936), on the other hand, made chromosome counts on the same species to prove that the whole "schizogony" (growth) phase and part of the sporogony phase is diploid, and that the haploid phase occurs only in the latter stage of sporogony and ends with the fusion of the sporoplasm nuclei after it issues from the spore on germination. Each nucleus possesses four chromosomes. At the end of spore formation both gamete nuclei may be found in the division process. From each of these nuclei two chromosomes become surrounded by a nuclear membrane, while the remaining chromosomes in the cytoplasm near the gametes soon become absorbed. In each case the mature spore contains an ameboid stage, with two nuclei whose two chromosomes are united into a karyosome, and the last division in sporogony is thus found to be the reduction division. Georgévitch also worked on *Myxidium*, *Henneguya*, *Myxobolus*, and *Sphaeromyxa*, and in each genus he found the same general type of diploid cycle. Debaisieux (1925) believed that his observations on *Sphaeromyxa* tended to confirm those of Georgévitch, but he felt that further confirmation was needed.

A few authors have failed to find evidence for a reduction division, and have therefore concluded that sexual phenomena do not exist. (See Davis, 1916, 1923; Erdmann, 1917b; Schuurmans-Stekhoven, 1919.)

Although in most species there are two nuclei in the sporoplasm, some authors have described several (Mercier, 1909, and Keysselitz, 1908, in *Myxobolus pfeifferi*), and others have described but one (Stempell, 1919, in *Leptotheca coris*). Schuurmans-Stekhoven (1919) believed that in *Myxobolus swellengrebeli* the sporoplasm nuclei are derived from the division of two nuclei. In *Sphaeromyxa sabrazesi*, as described by Debaisieux (1924), four sporoplasm nuclei are formed from the original two, but two of these soon degenerate.

Georgévitch (1929) has pointed out that when the gametes are formed in the interior of the sporoblast, as in the majority of the cases of myxosporidian species, the sexual phenomena in

reality constitute a paedogamy. All the cells of the spore are derived from a single sporoplasm nucleus. Davis (1923) stated that fusion of the two sporoplasm nuclei is "simply a case of autogamy," and if there is true exogamy in the life cycle it must occur shortly after the germination of the spores and previous to the onset of sporulation. Dunkerley (1925) also expressed the opinion that the union of the two gamete nuclei in the spore is a form of autogamy, because all nuclei in the cyst of such species as *Agarella* or *Henneguya* are derived from one original amebula nucleus. He pointed out that the two sporoplasm nuclei in any spore are probably derived from different nuclei in the same cyst, and therefore are separated in origin from one another by perhaps many generations of nuclear divisions. These divisions represent many cell divisions in free living protozoa such as *Paramecium*, or several schizogony cycles in the Coccidia.

Schröder (1907) attempted to trace the lineage of each cell of the spore structure in *Sphaeromyxa sabrazesi*. He stated that there is no doubt that the gamete nuclei of the sporoplasm are derived one from the large and the other from the small original nuclei of the binucleate pansporoblast. In this interpretation the residual nuclei represent reduction products, and the fusion of the gametes is not a form of autogamy. According to Schröder's view all of the spore parts, with the exception of one gamete nucleus, are derived from one of the original pansporoblast nuclei. The latter nucleus, however, is definitely of a different type than the second original pansporoblast nucleus, which also gives rise to a spore. Such behavior is not in accordance with the history of pansporoblast nuclei as described for certain other species, where one nucleus gives rise to both spores and the second original nucleus forms only the residual nuclei (fig. 9). Schröder's scheme of cross fertilization fails in monosporous forms. Paedogamy is said to occur in *Leptotheca ohlmacheri* and in *Unicapsula muscularis*. In each of these species two separate sporoplasms exist, each with a single nucleus. In general, it may be stated that fertilization in the Myxosporidia is an autogamy.

In the cycles described by the writer (1941, 1943) the two gamete nuclei are derived from the same parent nucleus (fig. 13). One may naturally ask the question, "What is the significance of a fertilization of two nuclei or cells which are derived from a common parent nucleus or cell?" Sexual reproduction produces variations because of new combinations of chromosomes and genes. But in the Myxosporidia a set of four chromosomes may separate into two sets of two, thus forming two gametes which promptly reunite to form a single set of four chromosomes again. Even in the scheme proposed by Georgévitch, where the reduction division results in a loss of part of the chromatic material, the chromosomes which unite at fertilization have still been derived from a common nucleus, although two generations have intervened between that parent cell and the gametes. It seems unlikely that any changes have occurred in the genes of the two gametes to result in any benefit from new combinations of hereditary traits. This phenomenon

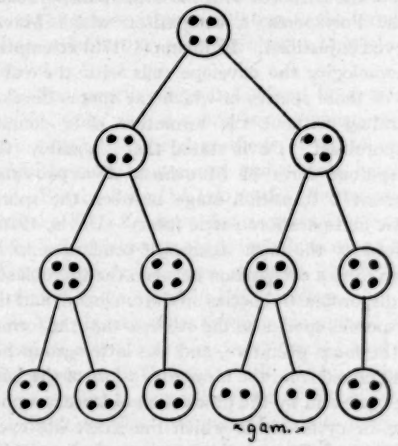

FIG. 13. CELL LINEAGE AND CHROMSOOME REDUCTION IN SPOROGONY AS DESCRIBED BY NOBLE

again raises the old question on the necessity for recombinations of genes.

Two possible explanations may be given. One of these is based on the degenerate nature of much of the characteristics of such a parasitic organism. The Myxosporidia are highly specialized parasites which have lost many of the characteristics which would be necessary for any free living organism. The need for and the mechanism of a normal sexual reproduction may be one of the characters which have been modified. A second possible explanation is that in this respect the Myxosporidia illustrate a primitive condition. Sexual reproduction must have followed asexual multiplication in the ancestors of modern unicellular organisms. A logical beginning of fertilization would be a union of

two closely related nuclei. This fertilization by autogamy would gradually be followed by a union of two more distantly related nuclei (paedogamy), then by unrelated cells. Such a union of closely related nuclei occurs in the Myxosporidia.

RELATIONSHIPS

The above discussion naturally leads to a consideration of the relationships of the Myxosporidia. First, the relations between the groups within the order Myxosporidia should be clarified. Mavor (1916) believed that the two residual nuclei of the pansporoblast in the Polysporea are obviously to be compared with the two trophonuclei of the Disporea. Doflein (1909) compared the sporoblast of the Disporea with the entire pansporoblast of the Polysporea, a comparison which Mavor believed unjustified. Erdmann (1917b) attempted to homologize the envelope cells with the valve cells of those species in which the spores develop separately without the formation of a definite pansporoblast. Davis stated that "possibly the polysporous form of *Sinuolinea dimorpha* may represent a transition stage between the sporoblastic and pansporoblastic forms" (Davis, 1916).

Probably the most significant conclusion to be drawn from a comparison between the sporoblastic and disporoblastic species on the one hand, and the polysporous species on the other, is that the former are the more primitive, and the latter group has been derived from the former by a loss of the budding cycle and by the production of larger trophozoites or cysts within which the entire life cycle takes place. The relationship suggests that which exists between the schizogregarines and eugregarines, where the schizogony cycle is absent in the latter group.

While comparing the Myxosporidia with other Sporozoa, Georgévitch (1926) likened the "mictosporous" *Coccomyxa morovi* to the Microsporidia. *Coccomyxa* is characterized by only one capsule in the spore. Naville (1930) described the formation of gametes in *Myxidium incurvatum* by a process of plasmotomy involving two small and two large nuclei. This phenomenon of sexualization is analogous to that which occurs in certain Coccidia (*Klossia helicina*). Schuurmans-Stekhoven (1919) found a similarity in the spore structure of of Myxosporidia with several rhizopods.

Naville produced evidence for a phylogenetic connection between the Myxosporidia and Haplosporidia, and between Microsporidia and Actinosporidia. The Microsporidia represent a general tendency towards isogamy resulting from a late sexualization, whereas the Actinomyxidia illustrate a reverse tendency towards the dioecious condition by the precocity of the sexualization which occurs after the second kinesis of the young pansporoblast. The three-valved spore of related Actinomyxidia is formed in an analogous way from three nuclei. Dunkerley (1925) also likened the union (autogamy) of the two gamete nuclei in the myxosporidian spore to paedogamy of Actinomyxidia instead of to autogamy of *Actinosphaerium*. He also pointed out that whereas in gregarines and Coccidia cysts and spores can be formed without requiring the specialization of a definite cell or nucleus, in the Myxosporidia we have a complete specialization of cells to subserve the process of syngamy in another cell, the amebula.

It has been suggested that the Myxosporidia are really Metazoa or at least related to the Mesozoa, especially to the Dicyemidae. Dunkerley (1925) stated that physiologically the spore of a myxosporidian is a multicellular unit analogous with the infusoriform embryo of *Dicyema*. He pointed out, however, that the Myxosporidia exhibit relationships with the rhizopods, whereas the Mesozoa are probably derived from ciliated ancestors. He suggested that the Myxosporidia may present a physiological explanation or reason for the origin of a soma; that reason being the need for a protective accessory to germ cells. Dunkerley was impressed with the fact that any of the various interpretations of pansporoblast formation points to the non-protozoan character of the Myxosporidia, "and the currently accepted explanation (involving as it does, segmentation of an individual organism) would be even more decided in this respect than" an explanation based on zygote formation at the start of sporogony. Probably the most significant comparison between the Mesozoa and the Sporozoa, however, is the generalization that both groups are characterized by complicated life cycles with an alternation of asexual and sexual phases.

Thelóhan (1890) thought that the mechanism of polar capsule formation offered many analogies with that which has been observed by Bedot in the nematoblasts of certain coelenterates (*Vellela, Physalia*). One may also point out the similarity between myxosporidian polar capsules with the trichocysts of certain Dinoflagellata (*Polykrikos*).

Debaisieux (1924) concluded that nuclear kinesis in Myxosporidia is only partially comparable to that in the metazoan cell, because he thought that in *Sphaeromyxa* the formation of chromosomes resulted from a quantitative distribution of chromatin but not a qualitative distribution, and that the number of chromosomes in one plasmodium may vary. These observations do not agree with those of other authors.

The Myxosporidia are unquestionably similar to the Metazoa in certain respects. Consider, for example, the genus *Myxidium*. The zygote of this myxosporidian parasite gives rise, by nucleogony and cytoplasmic growth, to a multinuclear body. As more nuclei are formed the older ones become surrounded by delimited cytoplasm. Thus the body becomes multicellular. The cells of the body then begin to exhibit differences in function. Specialization of function of somatic cells results in spore formation. Spores possess somatic and reproductive cells, with a division of labor (capsule and valve cells) among the former.

The presence of a multicellular body with a division of labor and interdependence among the somatic cells is usually considered as the primary difference between the Metazoa and the Protozoa.

These observations lend support to the conclusion that the Protozoa and the Metazoa are fundamentally alike. They also emphasize the danger of drawing any fixed rules of separation between Protozoa and Metazoa. Finally, they indicate that the order Myxosporidia is a highly specialized group of protozoan parasites which have become modified to possess basic metazoan characteristics.

One of the ways in which the Metazoa might have been derived from the Protozoa is by the appearance of cell boundaries in a multinucleate syncytium, but it is not to be concluded that there is any phylogenetic afinity between Metazoa and Myxosporidia. The specialized parasitic habit of the latter group makes any such comparison unconvincing. Affinity between the Myxosporidia and the Metazoa is one of convergent adaptation.

SUMMARY

1. The typical myxosporidian nucleus consists of peripheral chromatin and a large eccentric karyosome. During mitosis the karyosome often forms centrioles which may be abortive. Spindle fibers are common, and four chromosomes from the peripheral chromatin appear in the majority of species. The karyosome contains both chromatic and non-chromatic material.

2. True schizogony does not exist in the Myxosporidia. Asexual multiplication occurs in monosporous and some disporous species in the form of budding or plasmotomy, but this multiplication is a secondary process accompanying spore production. The entire life cycle of the large polysporous species generally occurs within the original zygote membrane. Multiplication in these polysporous species is accomplished largely by nucleogony (the formation of a syncytium) and cytoplasmic growth. Nucleogony takes place simultaneously with and in addition to sporogony.

3. The growth phase of a myxosporidian life cycle includes the period of nuclear multiplication from the zygote after sporulation to the formation of a sporoblast or pansporoblast. This phase is diploid.

4. The growth phase is followed by sporogony which begins with a sporoblast or pansporoblast. The various described methods of pansporoblast formation can be grouped under three headings:

A. By the fusion of two nuclei (formation of a synkaryon). Evidence for fertilization immediately before sporogony is not conclusive, and much of it appears to be based upon an interpretation of figures to be found in the literature.

B. By plasmogamy (cytoplasmic union). Evidence for plasmogamy has been largely based upon the presence of binucleate cells. Mitosis in the Myxosporidia, however, frequently occurs without spindle formation, and it is difficult to determine whether a given binucleate cell has been formed by union or by nuclear division.

C. By the differentiation and growth of a single cell without previous union of nuclei or of cytoplasm. The pansporoblast (or sporoblast) is derived from a specialized cell which begins as an ordinary vegetative cell or nucleus. Such an interpretation covers all observable figures in fixed and stained preparations, and it presents a logical, simple process without resort to the complications of a double fertilization or plasmogamy.

5. Sporogony may be monosporous, disporous or polysporous, and all three phenomena may occur in one species. Sporoblasts of six to eight nuclei, or pansporoblasts of fourteen (occasionally sixteen or seventeen) nuclei may be formed. A division in the latter group into two sporoblasts occurs, each sporoblast usually containing six generative and two somatic, residual nuclei.

Of the six generative nuclei two form the thin-walled shell valves; two give rise to the polar capsules each containing a polar filament; and two by a reduction division, become the haploid, sporoplasm nuclei or gametes.

6. Chromatic reduction in the spore usually occurs with the last division in sporogony. Georgévitch described a pinching off of two chromosomes from each of the two sporoplasm nuclei. Noble described a meiotic division of one of the sporoblast nuclei to form the two sporoplasm gametes without loss of chromosomes. Naville described a reduction soon after pansporoblast formation near the beginning of sporogony. Thus, according to various authors, the sexual process of gamete formation occurs at different periods of the life cycle in different species. Most of the recent authors agree, however, that the myxosporidian life cycle is mainly diploid. The sporoplasm nuclei may fuse before or after sporulation. This fertilization is an autogamy.

7. The sporoblastic and disporoblastic species are more primitive than the polysporous forms. The myxosporidian parasite is a multicellular body with a division of labor and with interdependence among the somatic cells. The order Myxosporidia consists of a highly specialized group of protozoan parasites which have become modified to possess some basic metazoan characteristics.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to B. H. Willier, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, Homewood Campus, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

BRIEF NOTICES

GENERAL BIOLOGY

A CONTRIBUTION TO THE THEORY OF THE LIVING ORGANISM.

By W. E. Agar. Melbourne University Press, Melbourne; Oxford University Press, London. 12s. 6d. 8½ x 5½; 207; 1943.

Theoretical biology has been preoccupied in the last few decades largely with the aspect of unity (wholeness) that is so characteristic of living organisms. The study of animal behavior and sensory reception, on the one hand, and morphogenesis, on the other, have contributed the most striking examples of this unity of organization. It is therefore not astonishing that theoretical biology today is building largely on the results of psychology and experimental embryology. W. E. Agar, the well known Australian student of cytology and animal behavior, bases his discussion mainly on concepts of animal psychology. The study of the organism becomes the study of the behavior of cells and cell aggregates on different levels of integration, and thus a striking unification of the biological and psychological level is made possible. To let the author speak: "The main thesis of this book is that all living organisms are subjects; that all but the simplest organisms (and possibly even these also) are organizations or nexus of subjects; that the characteristic activity of a subject is the act of perception; and that perception is the establishment by the subject of its causal relation with its external world." Is it, however, justifiable to introduce psychical factors into the study of cells and tissues? "A biologist, unless he takes the position that he is radically unique among living organisms, is concerned with experiencing subjects whether they be his fellow men, lower animals, tissue cells or even simpler organisms. Therefore it is not only legitimate but, as we shall maintain, necessary, for him to include in his explanatory schemes factors which are unnecessary for the explanatory schemes of the physicist—namely, such concepts as memory, anticipation, purpose, final causation—in a word perception." Indeed such mental factors are not more mysterious than physical concepts. Even predominantly experimental workers like Spemann have used psychological concepts for the interpretation of embryological processes. Basing his thought largely on the Gestalt theory of Koehler and Koffka and on Whitehead's philosophy of the organism, Agar develops a picture of the living organism as a psycho-physical system. The organism develops into a subject through concrescence of subjects (cells and organs) during embryogeny. Any nexus of activity acting as a unit is called an "agent." A cell, an organ, the organism as a whole are agents. The behavior of the organism as a whole is due to the "Central Agent," which is the expression of the activity of the nervous system. The action of this Central Agent leads to two important phenomena: the experience of continuity of existence and of unity. "Once constituted the continuity of experience of the Central Agent is due to the feeling by each actual occasion of feelings of its subagents, and also of the preceding actual occasion of the Central Agent itself."

Perception is the fundamental characteristic of every subject. "An act of perception is the establishment by the subject of its causal relation with its external world at that moment." It involves cognition, conation, and affective tone, and has anticipatory character. Thus the response to a stimulus is appropriate to a future situation; for instance, the avoidance response to a painful stimulus is appropriate to anticipation of a future relief of pain. Perception is present wherever life is present. Consciousness is not necessarily connected with it, but is rather a late evolutionary addition.

The animal as a whole is a subject, and its actions may be interpreted on the basis of the theory of perception. This Agar undertakes in a chapter on animal behavior in terms of perception. But cells are also

subjects, and the author devotes a chapter to interpreting embryonic development in terms of perception. Cells perceive like organisms and act like organisms; they "behave." Biological fields provide stimuli, genes determine the type of reaction. In instinctive behavior organisms strive toward a "hormic goal" (e.g., act of mating) without being aware of or considering the "biological consequences" of their action (e.g., continuation of the species). In a similar way cells behave actively during morphogenesis, attain certain hormic goals (e.g., lens formation, gastrulation) without considering the biological consequences (e.g., differentiation, maintenance of the individual). As developed in the final chapter, on evolution, it is random variation and selection that account for the organized interplay of hormic goals leading to the development and maintenance of individual organisms as well as of types of organisms.

The discussion is often not easy reading. Yet the ideas developed in this book should be carefully thought through by all those interested in the theory of the living organism, as well as by the students of behavior and morphogenesis. The arguments are certain to provoke debate and also disagreement, but undoubtedly should prove stimulating in many fields of biology.

MAURICE ARTHUS' PHILOSOPHY OF SCIENTIFIC INVESTIGATION. *Preface to "De l'Anaphylaxie à l'Immunité," Paris, 1921.*

Translated from the French, with an Introduction, by Henry E. Sigerist. Foreword by Warfield T. Longcope. The Johns Hopkins University Press, Baltimore. 75 cents. 10 x 7; 26; 1943.

In 1921 Maurice Arthus, for twenty-five years professor of physiology at Lausanne, and one of the first and most original workers in the field of anaphylaxis, felt the urge to introduce one of his technical treatises with a general preface, where he gave, to the profit of the younger generation, the quintessence of his thought about the basic technical and moral approach necessary for a young research worker. The short manifesto contains nothing new; fundamentally it paraphrases the ideas which have found their classic expression in Claude Bernard's *Introduction à la Médecine Expérimentale.* Whether the strong opposition between "peaceful and solid classifying of facts" on the one hand and "quarrelsome elaboration of theories" on the other hand, established by Arthus, is justified or not, is open to doubt. And there may be some causal connection between the victory of the author's ideas and the fact he already complained of in 1921, that the "scientific work of our young people today is often so dull, so colorless and so sad." Nevertheless, because of its sincerity, conciseness, and beauty the little essay deserved well to be saved from oblivion and made accessible to a larger public. It is so necessary to think over, once in a while, our fundamental methods and approach; and rare are the occasions to do so. The older generation will enjoy finding in this little book a masterful formulation of its creed; the younger generation will be touched by its faith and will be able to learn much from it. The introduction and the translation of Prof. Sigerist are both equally excellent.

THE HIPPOCRATIC OATH. *Text, Translation and Interpretation. Supplement to the Bulletin of the History of Medicine No. 1.*

By Ludwig Edelstein. The Johns Hopkins Press, Baltimore. $1.25 (paper). 10 x 6¾; vii + 64; 1943.

Dr. Edelstein has submitted to historical analysis a document which has played an enormous role in the crystallization of medical ethics up to this day. He shows that injunctions of the oath, like the interdiction of giving poison for suicidal purposes or abortive drugs, do not at all agree with the general attitude of ancient physicians but point to one philosophical sect as the originators of the oath: the Pythagoreans of the fourth century B.C. He makes the same point for the attitude towards dietetics and surgery, justice and continence, the relation between pupil and teacher, as they are formulated in the oath. The oath obtained general validity only when a new religion, in agreement with Pythagorean ethics, became dominant. This was Christianity.

In throwing new light on an obscure question, and in giving a concrete historical sense to precepts which have often been taken as eternal attributes of medicine, the author has not only made a valuable contribution to our knowledge of ancient medicine, but to a sound analysis and reformulation of medical ethics. His scholarly and eloquent presentation of the problem will captivate all scientists and physicians whose interests transcend the narrow limits of their specialty.

COLLEGE BIOLOGY. *Third Edition.*

By Walter H. Wellhouse and George O. Hendrickson. F. S. Crofts and Company, New York. $3.25. 8 x 5¼; 391; 1944.

The present edition of this fine text follows closely the pattern of presentation exhibited by the earlier editions. It has been written especially for use by general college students, although ample provision has been made for students who desire a broader and deeper knowledge of biology.

The discussions cover the structures, functions, and interrelationships of a large series of organisms ranging from the simplest one-celled forms through the more complex forms to the primates. Various type organisms, such as the leopard frog, are presented in great detail in outlining the important biological principles.

Chapters on such related topics as taxonomy, paleontology, behavior, heredity, and evolution are included.

The brief topic headings at the beginning of each chapter, and the list of references at the end of each chapter enhance the value of the text for review work or collateral study. The illustrations are pertinent and well chosen. A detailed index is provided.

SIMPLE EXPERIMENTS IN BIOLOGY. *Compiled by Cyril Bibby. William Heinemann, Ltd., London.* 7s. 6d. 7¼ x 4¾; xii + 164; 1943.

Much careful thought and planning have gone into the preparation of this little volume. Since it has been written to fill a specific need in wartime Britain, it will probably find greater usefulness there than in the United States.

The scope of the experiments herein outlined is of sufficient breadth to accommodate a considerable range of student abilities and classroom techniques. Thus, we note a number of exercises which could be selected for use in Senior high school work, while there are others which appear more suitable for Freshman or Sophomore college courses. Some of the experiments can be carried out best by students singly, others are more adaptable to students working in pairs or groups, while still others are best suited for lecture-demonstrations by the teacher. The work is intended for use not as a laboratory manual to accompany any specific text, but as a guide and handbook to be used in conjunction with any good standard biology text, in helping the student obtain a working knowledge of the materials and principles of biology.

The exercises are built up around broad physiological and biological principles, and ample use is made of both plant and animal forms in demonstrating these principles. The work is devoid of any illustrative material, but a helpful list of references is appended.

A BIOLOGICAL SURVEY AND FISHERY MANAGEMENT PLAN FOR THE STREAMS OF THE LAKE SUPERIOR NORTH SHORE WATERSHED. *Technical Bulletin No. 1.*

By Lloyd L. Smith, Jr. and John B. Moyle. Minnesota Department of Conservation, Division of Game and Fish, St. Paul. Free (paper). 9 x 6; 228; 1944.

EVOLUTION

CLIMATE AND EVOLUTION. *Second Edition, Revised and Enlarged. Special Publications of the New York Academy of Sciences, Volume I.*

By William Diller Matthew. Arranged by Edwin Harris Colbert. Preface by William King Gregory. Critical Additions by the Author and Others, and Bibliography of Matthew's Scientific Works by Charles Lewis Camp and Vertress Lawrence Vanderhoof. New York Academy of Sciences, New York. $2.00.

9¼ x 6; xii + 223; 1939.

In 1915 the late paleontologist Matthew published his classic essay on "Climate and Evolution," for which there has been so continuous a demand that the first edition has long ago been exhausted. The present, highly welcome volume was planned primarily as a reprint of the 1915 paper, carefully revised by Dr. E. H. Colbert on the basis of later annotations by the original author. To this monographic publication have been added a few short studies by Matthew, bearing on the same general topic. The following titles have been reprinted from other journals: "Affinities and Origin of the Antillean Mammals" (1918); "The Dispersal of Land Animals" (1930); and "Tables Showing Past and Present Zoögeographical Distribution of Land Mammals" (1928). A "Note on the Wegener Hypothesis, Etc. Supplementary to *Climate and Evolution*" had been found among Matthew's manuscripts and is here printed for the first time. Included in the volume are also "Some Remarks upon Matthew's *Climate and Evolution*" by Thomas Barbour, and the reply to the latter critique by Matthew, first published in 1916. This book has been further enriched by a biographical sketch, written by Dr. W. K. Gregory, by an excellent portrait, and by an annotated bibliography of William Diller Matthew's works.

In these various studies Matthew demonstrated that secular climatic changes have been the principal cause of the evolution and present distribution of all major groups of terrestrial vertebrates. The main migration routes of the latter all radiated from centers in the northern continental regions. According to Matthew there is no need for assuming the numerous hypothetical bridges between tropical and southern land masses which have frequently been advocated in explaining the geographical distribution of vertebrates. The paleontological facts, assembled here, strongly support the theory that "it is the environment itself, biotic as well as physical, that migrates, and the primitive species are those which have followed it, while those which remained have had to adapt themselves to a new environment and become altered thereby." This fundamental thesis of Matthew's original study has been ably and consistently upheld in his later writings, which furnish additional evidence and illustrate the complexity of the entire fascinating problem of the connection between cyclic changes in climate and the evolution and distribution of land animals.

SAN FRANCISCO BAY AS A FACTOR INFLUENCING SPECIATION IN RODENTS. *Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 59.*

By Emmet T. Hooper. University of Michigan Press, Ann Arbor. $1.25 (paper). 10 x 6½; 89+5 plates; 1944.

Major geographical barriers are well known to have important influences on zoological distribution, but minor barriers often provide better opportunity for basic studies of environmental effects and speciation in general. The present one is restricted to the San Francisco Bay area of west-central California. Rodents were collected from around this area and were then intensively studied with respect to coloration, surface dimensions, size and shape of skeletal parts, ecological distribution, and other pertinent comparative criteria. As a result of the distribution of the 43 species and subspecies recorded, the author recognizes two rodent faunal areas, four faunal subareas, seven districts, and nine ecologic associations. Each faunal division has two or more rodents and a set of environmental conditions peculiar to it.

Of primary interest is the division between the humid coastal belt, which extends inland a considerable distance because the Bay acts as a highway over which cool moisture-laden winds travel unimpeded, and the drier inner coast region. Each of these is divided into a northern and southern half by the Bay. The Bay itself is surrounded by marshlands which contain three endemic species of rodents and therefore forms a fifth major district.

"In environmentally different coastal and inland belts in the bay area, the intraspecific differential characters of at least 5 species of rodents parallel the latitudinal gradients which are apparent as between those coastal and inland areas. The differential characters are principally of size and color and appear to have evolved in response to some selective force in the environment that governed the direction of their evolution."

The Bay itself acts as a barrier to north and south distribution, as eight of the species north of the Bay are absent from the south side, and five are limited to the south, although in each case some of the species may range to the water's edge. Distinct subspecies are also isolated by this barrier. The differences between the forms north and south of the Bay have no apparent adaptive significance and no environmental correlation can be discerned, hence "the evolution of most of the differential characters apparently has rested mainly on chance fixation. . . ." The differential characters distinguishing the coastal and inland species, on the other hand, appear to be adaptations to the differing environments.

The present physiography and climate of the area, as well as its geologic history, are described. Within the account of each species are included its range, its habitat, and cogent remarks about it that often include tables of measurements. Maps facilitate quick comprehension of the distributions.

BOTANY

GARDEN ISLANDS OF THE GREAT EAST. *Collecting Seeds from the Philippines and Netherlands India in the Junk "Chêng Ho."*

By David Fairchild. Charles Scribner's Sons, New York. $3.75. 9¼ x 6½; xiv + 239; 1943.

In 1939, when Mrs. Anne Archbold offered to outfit an expedition, using a specially designed Chinese Junk, for the exploration of the Moluccas, the "Spice Islands," David Fairchild realized a lifelong ambition. Everyone who has read *Exploring for Plants* and *The World Was My Garden* will delight in this book, which is an adventure story as well as a recording of scientific exploration in strange and beautiful places. Dr. Fairchild's energy and enthusiasm have always been directed toward the introduction and adaptation of those tropical plants which can be used as sources of food in other countries.

This particular collecting trip was to have started from Manila in the fall of 1939, but just as the Fairchild party was about to cross the Pacific, war broke out in Europe. In spite of the hazards which confronted them, the Fairchilds decided to continue, and for several months they roamed the southern Pacific waters. Then the Germans invaded Holland in May, 1940, and the Japanese tide began to roll over the islands of the Great East, forcing the "Cheng Ho" to head back to the Philippines. The story of this expedition is told with bits of typical Fairchild philosophy, a quaint and quiet humor, and a sincerity that leaves the reader with a warm and friendly feeling for the author. Dr. Fairchild is not only distinguished as a botanist, but as a weaver of interesting tales of far-off and fascinating places. He describes things that the ordinary traveler looks at but never really sees.

The book is profusely illustrated with exquisite photographs, mostly by Dr. Fairchild, some by Edward Beckwith; the ingenious and decorative end papers are the work of Professor Raisz of Harvard University. Just as the author here followed the trail of his 19th century naturalist, Alfred Russell Wallace, so other young biologists cannot fail to feel the urge to emulate Dr. Fairchild. May they succeed as well as he has succeeded.

PLANTS OF THE NIAGARA PARKS SYSTEM OF ONTARIO.

By George H. Hamilton. The Ryerson Press, Toronto. $4.00. 10½ x 7⅛; xiii + 233; 1943.

This book is a very useful by-product of the activities of the Niagara Parks Commission, which since its establishment sixty years ago has developed a system of parks and boulevards extending along the margin of the Niagara River from Lake Ontario to Lake Erie, including well planned and extensive gardens of various types, and developing the unsurpassed scenic beauty

of the region, preserving its natural features and protecting and fostering the wealth of wild plant life. The school for apprentice gardeners established by the Commission some eight years ago, following the basic principle of collaborating with nature, has offered training in practical gardening and awakened a realization of the value of the native flora and the need for its preservation. The author, botanist of the Parks Commission, during his years of service on the staff of this school has catalogued the native flora of the Park system, and mindful of the fact that the system is a natural center for nature-loving tourists who come in great numbers through Niagara Falls as the principal gateway into Canada, has offered this book to the public as a popular contribution in response to repeated demands for information regarding the flora of the vicinity. The purpose of the book is primarily to enable visitors to become acquainted with the unusual abundance of plant life which flourishes in the park system by furnishing descriptions chiefly of the more conspicuous and important of the wild plants, without any attempt to include the thousands of varieties of ornamentals which the park contains in its more formal plantings.

Nearly 900 species in about 422 genera are here described with a minimum of technical terms, their distinctive features are noted, and their names are given according to the nomenclature of standardized plant names of the American Joint Committee on Horticultural Nomenclature. Since common names differ in different regions, those of the Province of Ontario are included in many cases and it is probably to this that we owe such gems as the "Spearleaf Fat-Hen Saltbush" and the "Stinking Clammyweed."

The illustrations are a valuable feature of the book. The introductory chapter on plant structures has line cuts showing outlines of leaves and diagramming the parts of typical flowers as well as types of inflorescences, while three other line cuts show effectively the distinctive leaves and fruits of species of oak, the leaves of maples, and the structure of composite flowers. There are four colored plates, two of them showing more formal gardens and two wild flowers, while over seventy half-tones excellently supplement the descriptions. These are for the most part excellently illustrative, whether they show close details of floral structure or general views of the habits of trees. Some, unfortunately, are slightly vague; some, such as the cattail, distinctly decorative.

The descriptions occupy most of the book. The characteristics of the families are given briefly, the features of predominant members described, the presence of additional species noted. In addition an introductory chapter on plant protection asks the cooperation of the visitor, and notes that since the last catalogue of 1894 a number of genera can no longer be found, while other species, formerly common, only occur in remote spots where their inaccessibility has saved them. There is also a brief discussion of plant structure helpful to the non-botanical reader, while toward the end of the book a glossary is included for his benefit, and a list of fourteen references to other floras and texts that will prove helpful.

The general index is a useful one, species names being set in italics, those of families in full capitals, and common names in lower case. Especially interesting to the botanical reader is the index of families, genera, and species, which shows their proportionate representation in the flora.

The book is notably free from errors, only two typographical errors being apparent in careful reading. But such definitions as "oval, outline like that of a rugby ball" and "lanceolate, shaped like a lance," might prove somewhat disturbing to followers of Asa Gray. Also the characterization of the mustard family as a "large family that contains many of our most obnoxious weeds, a few ornamentals, and some plants of economic importance" hardly does justice to the agriculturally valuable Cruciferae.

Although designed primarily for popular use by the nature-loving visitor, this book should find a wide sphere of usefulness.

SHRUBS OF MICHIGAN. *Cranbrook Institute of Science, Bulletin No. 20.*

By Cecil Billington. The Cranbrook Press, Bloomfield Hills, Michigan. $2.50. 9 x 6; [249]; 1943.

This handy manual contains a description of nearly all the shrubs of Michigan. We say nearly, as the writer adopts a conservative viewpoint and does not attempt to include all the named forms of uncertain validity. For instance, he lists only four species of *Crataegus*; anyone wishing to pursue this genus further is wisely advised to consult the more technical publications. All the species are illustrated by line drawings of the leaves, fruits, and flowers. There are keys to the families and genera, and to the species when more than one belongs to the same genus, as well as outline maps of the State which indicate distribution by counties. The text contains precise descriptions of each shrub, its leaves, fruits, and flowers, the time of fruiting and flowering, and its general range.

Following a definition of a shrub, which the writer admittedly reveals is not very accurately determined, there are useful discussions on identification, collecting and preserving, brief notes on distribution and ecology, a list of shrubs attractive to the birds (although without stating which birds), and the etymology of generic names and the more common specific ones. The writer confesses that he is not a professional botanist; this fact has certainly not been a drawback, as this worthy and practical handbook ranks with the better state lists.

A Revision of the Genus Fuchsia (Onagraceae). *Alice Eastwood Semi-Centennial Publications No. 1. Proceedings of the California Academy of Sciences, Fourth Series, Volume 25, No. 1.*

By Philip A. Munz. California Academy of Sciences, San Francisco. $1.75 (paper). 10¼ x 6¾; 105 + 16 plates; 1943.

Although the plants of the genus *Fuchsia* are commonly used for horticultural purposes in this country, no recent taxonomic study has been made of them. Since many new importations have been propagated and are being used for hybridization and culture, the writer feels that it would be important to know what these species are and where they come from. Following a key to the species, each form is described, and its leaf and flower illustrated. The writer recognizes 100 species, some of which are here described for the first time.

Plant Viruses and Virus Diseases. *Second Edition, Entirely Revised.*

By F. C. Bawden. The Chronica Botanica Company, Waltham, Massachusetts; G. E. Stechert and Company, New York. $4.75. 10¼ x 6¾; xi + 294; 1943.

This second edition is especially welcome, since the first was out of print within a year after its publication in 1939 and its type was lost in the invasion of the Netherlands. Moreover, the rapid accumulation of considerable significant material gave additional reason for a revised edition, and it is more credit to the author that under wartime conditions he has brought the book up to date so successfully, extensively revised throughout, and over half completely rewritten.

The general arrangement of the subject matter is as in the first edition: a brief introductory survey; the symptomatology, external and internal; the relations with insect vectors; the complications of strains, mutants, acquired immunity, and serological reactions; the methods of purification and the properties of purified viruses; the inactivation of viruses; size of particles; physiology of diseased plants; classification of viruses; and control of virus diseases.

Throughout, the emphasis is on the viruses themselves rather than on the virus diseases as pathological complexes, the nature of the viruses as investigated *in vitro* being especially stressed. The controversial question of the classification of viruses is carefully weighed, and the advantages and disadvantages of each of the several warmly supported systems are judiciously evaluated. The conclusion is reached that classification on the basis of the biochemical nature of the viruses themselves as nucleo-proteins may prove the most helpful and dependable.

Control measures are well covered; the limitations imposed by the fact that infection is systemic and enduring are emphasized; the possible therapeutic procedures, such as heat treatment of cuttings, dependent on a differential between the resistance of the host protoplasm and the virus, are discussed; general preventive measures, such as roguing, the use of immune varieties, and the control of insect vectors, are considered.

The final discussion of certain theoretical aspects is stimulating and of general biological interest. Here are considered the nature of viruses, whether living or non-living, and the properties of viruses, compared with those of organisms, as well as the hypotheses as to their origin and their multiplication. All this leads to the conclusion that much more needs to be known of the activities of viruses *in vivo* rather than *in vitro*, before these questions can be answered.

The 48 half-tone illustrations adequately supplement the text; the vignettes of the first illustration of potato curl and of Clusius' 1583 woodcut of the tulip break, the oldest known plant virus disease, fittingly embellish it.

An Introduction to Pollen Analysis.

By G. Erdtman. Foreword by Roger P. Wodehouse. Chronica Botanica Company, Waltham, Massachusetts; G. E. Stechert and Company, New York. $5.00. 10¼ x 6¾; xv + 239; 1943.

A brief introduction discusses the historical background of this relatively recent field of scientific work and traces the start of modern investigations in 1916 and the rapid growth which has followed, growth in which Erdtman himself has played an outstanding part. As a basis for better understanding of the structure, endurance, and characteristics of pollen, the second chapter on the chemistry of peat, written by the author's brother and revised by Dr. Waksman, serves as a valuable introduction. Two chapters on the technique of preparing pollen for examination give in careful detail the equipment needed and the procedure followed in the complicated but successful method of acetolysis, which yields ideal material for study both in the case of recent pollen and in the case of fossil, pollen-bearing material from peat and brown coal.

A detailed description of pollen morphology, fully explaining the technical features of the sculpturing and composition of the wall, and supported by a glossary of three pages, prepares the reader for the study of representative types of pollen of monocotyledons, dicotyledons, gymnosperms and pteridophytes, occupying the major part of the book,—about 100 pages. Following this there are two chapters: one on the graphic presentation of the results of pollen analysis, giving the principles for computing the frequency of different categories encountered, the technique of presenting pollen spectra and the significance

of pollen diagrams and of isopolls; the other, a brief chapter on the stratigraphic correlations made possible by using pollen spectra in the manner of index fossils in their bearing on paleoclimatology and geology.

Following these essentially detailed chapters, the more theoretical and fundamental aspects of pollen analysis are discussed. Chapter 13 covers the output and dissemination of pollen and its differential buoyancy and consequent rate of sinking, with interesting data from Erdtman's own studies made with his modified vacuum cleaner conimeter while crossing the Atlantic from Gotenburg to New York. In the following chapter he discusses surface samples, comparing the different methods used and results obtained in presenting the pollen pictures of typical regions, emphasizing the accuracy with which they represent the flora of the present, and their applicability in evaluating the analyses of the flora and ecology of the past. The pollen of peat is then discussed in reference to such problems as the differential resistance of pollen, the significance of poller frequency, and the difficulties presented by the presence of secondary pollen in allocthonous sediments.

A comprehensive view of the progress in the pollen analysis of Quaternary deposits in different countries is afforded by the geographical survey compiled from the author's well-known and extensive lists. The work on the pollen analysis of Tertiary deposits is well covered, and the increasing accuracy and effectiveness of the investigations in recent years are noted. The brief discussion of pollen analysis of honey and drugs reveals unexpected potentialities, such as the scientific detection of falsified labelling and paleomelitological evidence from honey in Egyptian graves.

A list of 41 recent publications, chiefly American and not yet seen by the author because of war conditions, supplements the pertinent references that follow each chapter. The illustrative material is excellent, and the inclusion of 3 portraits of out-standing Scandinavian workers makes the reader wish that the editor had included here a portrait of Erdtman himself.

THE CITRUS INDUSTRY. *Volume I. History, Botany, and Breeding.*

Edited by Herbert John Webber and Leon Dexter Batchelor with the collaboration of Elbert Thomas Bartholomew, Homer Dwight Chapman, Howard Brett Frost, Walter Tennyson Swingle, Archibald Dixon Shamel, Howard Sprague Reed, and Walter Pierson Kelley. University of California Press, Berkeley. $7.50. 9¼ x 6; xx + 1029; 1943.

This book, one of a series commemorating the seventy-fifth anniversary of the founding of the University of California, is a milestone in its own right. It represents the first comprehensive treatment by Americans of a tropical or subtropical plant industry. Until now we have depended largely upon the Dutch, the British, the French, and the Germans for authentic studies upon the economic plants of the warmer regions of the world. The reason for this is obvious—the United States has had no colonial empire—but the condition is nonetheless deplorable and, in time of war, sometimes tragic. The situation in the case of the citrus fruits is exceptional. These can be and are grown in the United States on an enormous scale; much research has been done upon them, and the accumulated knowledge and experience that must serve as the foundation for a treatise of this kind is available.

The Citrus Industry marks still another important trend—a maturation in the standards of scholarship of the state agricultural experiment stations. Established almost seventy-five years ago, these institutions have grown and flourished. They have been eminently successful in solving many of the agricultural problems of this country and in establishing American agriculture upon a sound basis of applied science. The results of their research, however, have for the most part been published piecemeal in station bulletins and technical journals. This is the first attempt, in the reviewer's knowledge, to assemble in a thorough fashion all of the facts bearing upon a large and important American agricultural enterprise.

The present volume, the first of a series of three, is concerned with history, botany, and breeding, and is complete in itself. There are ten chapters, each written by a specialist on the subject. One of the most interesting chapters is the first, on the history and development of the citrus industry, by H. J. Webber. It illustrates in an incomparable fashion the way in which the history of economic plants is inextricably entwined with the history of mankind. The story of the citrus fruits touches upon the history of China, Europe, and America; upon the barbaric invasions, the rise of Mohammedanism, the migrations of the Arabs, and the discovery of the New World. It becomes obvious that one of the most fascinating approaches to history is that of following the peregrinations of an important food plant.

A most valuable chapter is that on the botany of citrus, by Walter T. Swingle. Here is the first complete treatment of the family in more than a century, written by a botanist who has devoted a lifetime to its study. Thirty-three genera and 203 species are considered. More than a quarter of a million microtome sections have been studied in arriving at the present basis of classification. The species are considered not only from the standpoint of their botanical relationships, but also from that of the useful characteristics which they have to offer for breeding purposes. Seldom has an economic plant received such competent taxonomic treatment.

Other notable chapters are those on reproduction and genetics and breeding, by Howard Frost. These two chapters constitute a miniature handbook on the

problems and techniques involved in citrus breeding, and provide adequate treatment of the special, in some cases unique, problems encountered in this group of plants.

The chapter on mineral nutrition, while excellent, strikes one as being out of place in this volume, and probably would be more appropriate to the second volume: *The Production of the Crop*.

The bibliography of more than a thousand titles is especially useful, for it has drawn extensively not only upon American literature, but has also brought together the less accessible literature of Italy, Japan, Palestine, Brazil, and other countries where the citrus fruits are economically important. The index is comprehensive and detailed.

It is to be hoped that the two additional volumes will meet the high standards set by the first, and that the completed work will serve not only as an incentive, but as a pattern, for other groups of agricultural scholars.

THE EMBRYOLOGY OF LARIX. *Illinois Biological Monographs Volume 19, Number 4.*

By James Morton Schopf. University of Illinois Press, Urbana. $1.50 (paper). 10½ x 7½; 97 + 6 plates; 1943.

The study of plant embryology is an extremely difficult undertaking, requiring much skillful collecting, painstaking observation, and careful analysis of available materials. Using the larch as the experimental organism for the present study, the author has made a worthy contribution to our knowledge of the gymnosperms.

The discussions cover the methods of collecting and preparing the experimental materials, the process of fertilization among the gymnosperms, the rate of growth and the sequence of embryonic development as related to the phylogeny of the gymnosperms, and the relationships between *Larix* and other members of the Pinaceae.

The author concludes that although the cellular structure of the gymnosperm embryo is relatively simple, its physiology must be extremely complex. Since the embryogeny of *Larix* differs only slightly in its early stages from that of the pine, the cleavage type is designated as "delayed cleavage polyembryony."

The work is carefully illustrated, and carries a bibliography of some 70 titles.

CONTRIBUTIONS DE L'INSTITUT BOTANIQUE DE L'UNIVERSITÉ DE MONTRÉAL. No. 44. Containing the following papers: *Quelques noms vernaculaires de plantes du Québec*, by Bernard Boivin; *Additions à la flore de l'île d'Anticosti*, by Jacques Rousseau; *Notes sur quelques introductions récentes dans le Québec*, by Barnard Boivan; *Asa Gray et la publication de la Flore de Provancher*, by Jacques Rousseau; *Les rhizoconcrétions argileuses et les balles sablées*, by Jacques Rousseau; *Un endémique de l'île d'Orléans: Amphicarpa chamaecaulis*, by Bernard Boivan and Marcel Raymond; *La forme naine du Plantago juncoides et d'autres espèces*, by Jacques Rousseau; *Le Cirsium minganense est-il une bonne espèce?* by F. Marie-Victorin, J. Rousseau, and M. Cailloux.

Université de Montréal, Institut Botanique, Montréal. 50 cents (paper). 9 x 6; 72; 1942.

LES VALLISNÉRIES AMÉRICAINES. *Contributions de l'Institut Botanique de l'Université de Montréal, No. 46.*

By Frère Marie-Victorin. Université de Montréal, Institut Botanique, Montréal. 25 cents (paper). 9 x 6; 38; 1943.

L'ÉRABLIÈRE LAURENTIENNE. I. Valeur d'indice des espèces. *Contributions de l'Institut Botanique de l'Université de Montréal, No. 45.*

By Pierre Dansereau. Université de Montréal, Institut Botanique, Montréal. 25 cents (paper). 9 x 6; 93; 1943.

ZOÖLOGY

MEDICAL PARASITOLOGY AND ZOOLOGY.

By Ralph Welty Nauss. Foreword by John C. Torrey. Paul B. Hoeber, Inc., New York. $6.00. 9¼ x 6½; xix + 534; 1944.

As the title implies, this book covers a broader field than the usual textbook of parasitology. In addition to discussing the protozoa, worms, and arthropods responsible for human diseases, the author also considers the coelenterates, mollusks, fishes, snakes, and lizards that are harmful to man. The presentation of each subject is clear and concise, and as complete as possible for a textbook of convenient size. The subject matter is free of extraneous data that would tend to confuse and alienate the student. Even useful relevant information has been removed from the main body of the text and placed in the appendix, to avoid distracting the student's attention from the essential aspects of the subject. In the appendix, one finds such topics as microscopic techniques, staining and cultivation methods for protozoa, procedures for concentrating eggs and cysts in feces, preservation of parasitological material, and a list of poisonous snakes found in the Western Hemisphere.

Ninety-five figures illustrate the morphology, life cycles, and geographical distribution of the organisms described in the text. Most of the figures depicting life cycles have been taken from Kourí and Basnuevo, *Lecciones de Parasitología y Medicina Tropical*. A particularly valuable feature of the book is the lengthy glossary. It is divided into two parts, 1st, Classifica-

tion of Animal Parasites and Arthropods, and 2nd, Definition of Terms. There is also a bibliography of original literature, standard texts, and periodicals. In all, this book should prove to be a worthwhile text for an undergraduate medical school course in parasitology.

A MANUAL OF MEDICAL PARASITOLOGY.

By Clay G. Huff. University of Chicago Press, Chicago. $1.50. 9½ x 6¾; x + 88; 1943.

This manual is an outgrowth of a mimeographed outline used in the course in Medical Parasitology at the University of Chicago for several years. Although it is, no doubt, particularly adapted to that course, it has been organized in such a manner that it can probably be used in most courses of parasitology offered in medical schools.

Each of the first ten chapters is concerned with a group of parasites that are morphologically similar or are located in the same organ of the host: (1) Trematodes, (2) Cestodes, (3) Nematodes, (4) Intestinal Protozoa, (5) Hemoflagellates, (6) Malarial Parasites, (7) Mosquitoes, (8) Flies, (9) Other Blood Sucking Insects, and (10) Ticks and Mites. In these chapters, such topics as morphology, life cycles, classification, and pathology are presented. Although the limited size of the book has made it impossible to include a complete account of any subject, it should serve as a helpful laboratory guide if the students have standard text books of parasitology readily available. A few sample keys are given in order to acquaint the student with that method of identifying various organisms.

The final chapter is devoted to laboratory methods of diagnosing parasitic diseases. The student is briefly instructed in the procedures for examining blood, cerebrospinal fluid, feces, and biopsy material for the presence of parasites. Serological and immunological methods of diagnosing certain parasitic infections are given some consideration.

The *Manual* is well organized and written. It contains ten excellent plates; however, its usefulness could have been greatly increased had there been more figures to illustrate the morphological details described in the text. The colored plate of the human malarial parasites clearly indicates the main differential characteristics of the three common species. A list of reference books and an index are included.

A HANDBOOK FOR THE IDENTIFICATION OF INSECTS OF MEDICAL IMPORTANCE.

By John Smart, with chapters on Fleas, by Karl Jordan, and on Arachnids, by R. J. Whittick. British Museum (Natural History), London. 15s. 9¾ x 7⅛; x + 269 + 13 plates; 1943.

In the preface, the author relates a present-day condition that makes this book exceedingly important and timely. Before the war if a person was faced with the problem of identifying an insect of medical importance, only one of two things could be done. He could obtain the necessary literature on the subject and identify it himself; or he could send it to an institution and request the aid of a specialist. Now lack of time and facilities usually prohibit solution of the problem by either of the customary methods. This is particularly true for those individuals concerned with identifying the insects that endanger the health of military personnel in remote corners of the world. In view of this situation, the author has endeavored to accumulate the information necessary to enable a person with an elementary training in entomology to identify those insects that produce or transmit diseases in the Old World.

The correct identification of an insect responsible for a disease in a given location is absolutely essential for effective control. Nevertheless, many books on parasitology and even entomology only superficially consider this phase of the subject. Here on the other hand, major emphasis is placed on identification and only bare mention is made of the diseases and their methods of control.

Although the author states that he assumes that the reader has an elementary knowledge of general entomology, he begins his book with an introductory chapter that presents most of the prerequisites necessary to understand the pages to follow. This opening chapter has the following subdivisions: Structure of Insects, Development and Life History of Insects, Classification and Nomenclature, and Zoogeography. With this information as a background, he proceeds to discuss the identification of the various groups of insects important in the field of medicine. These discussions are profusely illustrated by 178 figures and 13 plates (three colored). The keys for identification have been carefully organized and probably contain relatively few mistakes. The chapters on fleas and arachnids were not written by Dr. Smart but by two specialists, Dr. Karl Jordan and Mr. R. J. Whittick, respectively.

In keeping with the importance of malaria, one hundred pages are devoted to the identification of mosquitoes. The keys of the fourth stage larvae and adults are divided according to the four zoogeographical regions of the Old World, thus making eight keys in all.

Whenever a new group of insects is considered, the author presents any special techniques that may be needed in order to handle properly the specimens during their identification. In addition to this instruction in entomological technique, the last chapter is devoted to methods of collecting and preserving insects. Unfortunately, the book is almost exclusively concerned with insects of the Old World. Nevertheless, it would be a valuable addition to the library of

even those entomologists primarily interested in species of the Western Hemisphere.

THE ORGANIZATION OF PERMANENT NATION-WIDE ANTI-AEDES AEGYPTI MEASURES IN BRAZIL.

By Fred Soper, D. Bruce Wilson, Servulo Lima, and Waldemar Sá Antunes. The Rockefeller Foundation, New York. 11 x 8½; vii + 137; 1943.

This volume contains a comprehensive report of the Cooperative Yellow Fever Service, which was maintained jointly by the Brazilian Government and the International Health Division of the Rockefeller Foundation for eleven years, 1929–1940.

Before the organization of this Service, there were control measures in operation against yellow fever which were clumsy, expensive, and relatively ineffective. In spite of anti-mosquito campaigns in the principal cities, periodic epidemics of the disease continued to occur. By 1926 it was apparent that yellow fever transmitted by *Aedes aegypti* was still endemic in Northeast Brazil between, and including, the states of Bafa and Piauí. Through the efforts of the Cooperative Service, since August, 1934, no focus of yellow fever has been found within that region. As a matter of fact, no aegypti-transmitted yellow fever has been seen in Brazil since that date. Jungle yellow fever transmitted by other mosquitoes sporadically appears in certain localities.

The success of the program resulted not from the institution of radically new control methods, but from the careful, systematic application of accepted methods. The Service believed in the efficacy of species eradication rather than mere reduction in the number of mosquitoes. This eradication was extended from the cities and towns to the rural areas where aegypti-transmitted yellow fever was found to prevail. In 1940 the entire program was taken over by the Brazilian Government and is now being continued by the National Yellow Fever Service.

The book presents a detailed description of the organization and procedures of the Cooperative Service. It includes many photographs and drawings of various phases of the work, and numerous forms that were used for collecting and recording data. This record should be very helpful to those engaging in similar work.

THE CATFISHES OF VENEZUELA, WITH DESCRIPTIONS OF THIRTY-EIGHT NEW FORMS. *Proceedings of the United States National Museum, Volume 94.* (*No. 3172.*)

By Leonard P. Schultz. Smithsonian Institution, Washington, D. C. (paper); 9¾ x 6; 173–338 + 14 plates; 1944.

This report on the catfishes of Venezuela is based on collections made by the writer in the Maracaibo Basin and in other localities of the country, totaling 9920 specimens, as well as on additional specimens housed in the collections of the United States National Museum. Catfishes belonging to 11 different families, comprising 51 species and subspecies from the Maracaibo Basin, and 8 species and subspecies from the Orinoco system, were collected. Of these, six genera, 16 species, and 17 subspecies are described as new from the Basin, and four species and one subspecies as new from the Orinoco system. All specimens collected are described in great detail in the text; in addition the new forms are illustrated. There are extensive keys to genera and species, and numerous tables of measurements comparing closely related forms. Species not collected, but reported from Venezuela in the literature, are included with the others.

NORTHERN FISHES *with Special Reference to the Upper Mississippi Valley.*

By Samuel Eddy and Thaddeus Surber. University of Minnesota Press, Minneapolis. $4.00. 9 x 6; xi + 252; 1943.

More than 150 fresh-water fishes of the Northern Mississippi Valley area are described, over half of them illustrated by photographs, in this useful and informative manual. Keys are provided for the families, genera, and species to aid the interested sportsman, as well as the better trained ichthyologist, in identification. For each species there is a brief diagnostic written description, a summary of its range, and notes of interest on its biology.

The need for this book was created by the numerous requests for information about fishes and fishing made by fishermen and others in Minnesota. Since apparently half the resident population of the state are active anglers, and about 95,000 non-residents visit its fishing grounds annually, fresh-water fishing as a recreation and as a commercial enterprise is of major importance. Several chapters are therefore devoted to the conservation and management of fish, streams, lakes, and to the dynamics and ecology of an aquatic environment. The area included in this systematic survey comprises mostly Minnesota with its three great drainage systems, the Hudson Bay, the Great Lakes basin, and the Upper Mississippi River basin. Parts of Ontario, Manitoba, northern Iowa, Wisconsin, northern Illinois, North and South Dakota fall within the boundaries of the study.

THE FRESH-WATER FISHES OF CHINA. *Natural History of Central Asia, Volume IX.*

By John Treadwell Nichols. American Museum of Natural History, New York. $9.00 (paper); $10.00

(cloth, available after the war). 10⅞ x 8⅜; xxxvi + 332 + 10 colored plates; 1943.

This is the sixth volume of the proposed twelve to be published as the Natural History of Central Asia. It conforms to the high standards set by previous volumes. The report is based on collections made by the Central Asiatic Expeditions, and on smaller collections donated by individual collectors. Species listed in the literature as occurring in China are also included to make the review comprehensive. No attempt has been made to include marine species, or brackish-water species with marine affinities, though such may at times occur in fresh water. The area considered includes China proper, excluding such outlying territories as Manchuria and Mongolia.

The introduction discusses faunal relationships, and the history of the Ostariophysi which dominate the fish fauna of China. China proper appears to be a more or less unit faunal area, divisible into a southern and north-central subfauna, undoubtedly containing smaller subareas which only more extensive collecting will delimit. There is provided a list of fish whose identity can not be ascertained due to improper and incomplete original descriptions. At the end there is a supplement containing taxonomic changes and additions made from the time the manuscript was originally completed in 1935 to 1938. There is an extensive bibliography, 143 text figures, and ten plates of excellently rendered colored drawings. In spite of numerous delays, this important review has finally been completed to furnish a valuable survey of Chinese ichthyology.

EXPERIMENTAL MODIFICATION AND CONTROL OF MOLTS AND CHANGES OF COAT-COLOR IN WEASELS BY CONTROLLED LIGHTING. *Annals of the New York Academy of Sciences, Volume XLV, Art. 6.*

By Thomas Hume Bissonette and Earl Elmore Bailey. New York Academy of Sciences, New York. Paper; 9¼ x 6; 221–260 + 8 plates; 1944.

THE DISTRIBUTION OF THE SALAMANDERS OF THE GENUS PLETHODON IN EASTERN UNITED STATES AND CANADA. *Annals of the New York Academy of Sciences, Volume XLV, Art. 7.*

By Arnold B. Grobman. New York Academy of Sciences, New York. Paper; 9¼ x 6; 261–316; 1944.

A SYSTEMATIC REVIEW OF THE NEOTROPICAL WATER RATS OF THE GENUS NECTOMYS (CRICETINAE). *Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 58.*

By Philip Hershkovitz. University of Michigan Press, Ann Arbor. $1.15 (paper). 10 x 6¼; 101 + 1 folding map; 1944.

THE FRESH-WATER TRICLADS OF MICHIGAN. *Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 60.*

By Roman Kenk. University of Michigan Press, Ann Arbor. 50 cents. 10 x 6¾; 44 + 7 plates; 1944.

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY. *Vol. 46, No. 7, Two New Subspecies of Kangaroo Rats (Genus Dipodomys) from Southern California,* by Jean T. Boulware; *Vol. 48, No. 2, Systematic Review of the Chipmunks (Genus Eutamias) of California,* by David H. Johnson; *Vol. 51, No. 4, The Origin and Development of the Blood Island of Hyla regilla,* by Robert L. Fernald; *Vol. 51, No. 5, Fertilization of Coelomic Eggs of Triturus torosus,* by G. Merlin Good and J. Frank Daniel.

University of California Press, Berkeley. Paper; 10½ x 6¾; Vol. 46, No. 7, 25 cents, 6; Vol. 48, No. 2, $1.00, 85 + 1 plate; Vol. 51, No. 4, 35 cents, 19 + 1 plate; No. 5, 9 + 1 plate; 1943.

TRANSACTIONS OF THE SAN DIEGO SOCIETY OF NATURAL HISTORY. *Vol. 10, Nos. 1–7. On the Generic Relationships of Certain Californian Xerophile Snails,* by S. Stillman Berry; *New Mollusks from the Round Mountain Silt (Temblor) Miocene of California,* by A. Myra Keen; *Growth in the Western Blue-Tailed Skink,* by Thomas L. Rodgers and Biola H. Memmler; *A New Snake of the Genus Sonora from Lower California, Mexico,* by Laurence M. Klauber; *A Desert Subspecies of the Snake Tantilla Eiseni,* by Laurence M. Klauber; *The Coral King Snakes of the Pacific Coast,* by Laurence M. Klauber; *The Subspecies of the Rubber Snake, Charina,* by Laurence M. Klauber.

Society of Natural History, San Diego, Calif. Paper; 10½ x 6¾; No. 1, 24 + 2 plates; No. 2, 35 + 2 plates; No. 3, 7; No. 4, 2; No. 5, 4; No. 6, 8; No. 7, 8. 1943.

THE EFFECTS OF MILD HYPERTHYROIDISM ON GROWING ANIMALS OF FOUR SPECIES. *University of Missouri, Agricultural Experiment Station Research Bulletin 377.*

By Marvin Koger and C. W. Turner. University of Missouri, Columbia, Missouri. Paper; 9 x 6; 75; 1943.

BIOLOGY, ECOLOGY, AND MORPHOGENESIS OF A PELAGIC FORAMINIFER. *Stanford University Publications, University Series, Biological Series, Volume IX, No. 1.*

By Earl H. Myers. Stanford University Press, Stanford University. 75 cents (paper). 10 x 7; 40 + 4 plates; 1943.

MORPHOLOGY

A BIO-BIBLIOGRAPHY OF ANDREAS VESALIUS.

By Harvey Cushing. Schuman's, New York. $15.00. 10 x 7½; xxxviii + 229; 1943.

At Johns Hopkins, Harvey Cushing not only became the brain surgeon of world fame, but, like so many others, he was "inoculated" by Osler with the love of medical history and old medical books. For forty years he studied and collected the works of Vesalius, father of modern anatomy. He prepared this bio-

bibliography for the Four-hundredth Anniversary of the *Fabrica*. Cushing's death in 1939 left the book unfinished; but, under the general editorship of J. F. Fulton, the work has been completed by Arturo Castiglioni, W. W. Francis, E. C. Streeter, Mrs. John P. Peters, and Miss Madeline Stanton, and has been published on the occasion and in the year for which it was intended. The editors have done a remarkably good job. Unlike so many posthumous books, this bio-bibliography appears as a harmonious and lively whole.

Harvey Cushing himself regarded M. Roth's biography, F. M. G. de Geyfer's bibliography, and Spielmann's iconography as the fundamental works on Vesalius. Cushing's bio-bibliography is nevertheless, especially for the English-speaking countries, a very valuable addition to these books. The bibliographical analysis of each work of Vesalius is each time preceded by an essay on those episodes of Vesalius' life which surrounded the creation of the work under discussion. The bibliographical sections proper give detailed descriptions of all editions of every work (title in full, collation, summary of contents, commentarial notes, list of existing copies, and description of the copy used). An exhaustive bibliography of Vesaliana is added.

The book will be an indispensable tool for all those who intend to work on Vesalius. By its lively and personal style it will captivate far beyond these limits all those who are interested in Vesalius or Harvey Cushing. The splendid binding, print, and illustrations of the book enhance its value greatly.

A Text-Book of Histology *Arranged upon an Embryological Basis. Sixth Edition of "Lewis and Stöhr."* *By J. Lewis Bremer: Rewritten by Harold L. Weatherford. The Blakiston Company, Philadelphia.* $7.00. 9 x 6; ix + 723; 1944.

This text actually represents the sixth edition of the original Lewis and Stöhr text-book of histology. It has been re-edited and extensively rewritten by Harold L. Weatherford of Harvard University. Of the nearly six hundred illustrations, 302 are new; they are well chosen, and their reproduction is uniformly excellent.

The developmental approach to histology continues to be emphasized, based upon the belief that this is essential for an understanding of structure and function. In line with this, a section on placentation, written by Dr. George B. Wislocki, is included. The developmental aspect of histology is one that too often is neglected in current texts. The adult structure, although possessed of paramount interest for the student, is merely a phase, and its morphology and physiology cannot be truly understood unless this is appreciated.

The book is attractively printed, well indexed, and contains a literature list of more than seven hundred titles. In its new form, it continues to be one of the outstanding histological texts, and no doubt will find wide use.

The Skull of Sinanthropus Pekinensis: *A Comparative Study on a Primitive Hominid Skull. Palaeontologia Sinica, New Series D, Number 10; Whole Series Number 127.*

By Franz Weidenreich. Geological Survey of China, Pehpei, Chungking: G. E. Stechert and Company, New York. $10.00. 10 x 7⅓; xxxviii + 229 + 23 plates; 1943.

The remains of *Sinanthropus pekinensis* unearthed at Choukoutien, China, constitute perhaps the most important recent discovery of fossil man. Their study was begun by the late Davidson Black. Following his untimely death, the investigation was taken over by Franz Weidenreich, who since has published a number of papers dealing with the material. A monograph devoted to the mandible appeared in 1936, one dealing with the dentition in 1937, and another describing the skeleton of the extremities in 1941. An account of the skull, generally regarded as the *pièce de résistance* by anthropologists, was reserved for the last. It is with this part of the material that the present monograph deals. And, one may hasten to add, there seems but little doubt that this monograph represents the most significant single contribution to the recent literature on human evolution. It is a stimulating, challenging contribution, for many of the author's arguments and conclusions are anything but orthodox.

The 278 pages of text are divided into three parts: (1) An enumeration of the material (19 pages), (2) a detailed description of the material, including measurements (196 pages), and (3) a comparison of the skull of Sinanthropus with those of other hominids and anthropoid apes (63 pages).

The material described consists of 14 skulls, none of which is complete. Five are calvaria with or without basal parts, 4 are represented by more than one piece, and the remaining 5 are fragments of a single bone.

The general features of the sinanthropoid skull—a cranial capacity (estimated average, 1075 cc.) intermediate between those of Pithecanthropus (estimated at 775 cc. and 935 cc. for 2 specimens) on the one hand and Neanderthalians (estimated average, 1400 cc.) and modern man (average, ca. 1350 cc.) on the other, extraordinary thickness involving both tables and diploë, human orientation of the foramen magnum, and exceedingly prominent supraorbital ridges—already are well known. The many morphological details, which have been studied by Weidenreich with meticulous care, cannot be discussed here.

The following major conclusions of the author are of particular interest, and some of them no doubt will provide fuel for violent controversy:

(1) There is "danger of confusing anthropological facts with geological facts. In determining the character of a given fossil form and its special place in the line of human evolution, only its morphological features should be made the basis of decision; neither the location of the site where it was recovered nor the geological nature of the layer in which it was imbedded are important" (p. 1). (This is a cardinal tenet in Weidenreich's reasoning.)

(2) Sinanthropus and Pithecanthropus are the most primitive known hominids. The former, although closely related to Neanderthal types, is more primitive than any of that group. It is much closer to Pithecanthropus, differing in only 4 of 61 main characters.

(3) Eoanthropus (Piltdown man) should be erased from the list of human fossils. It is a "chimaera"—an artificial combination of a modern human calvarium with a mandible of the orang type. All recent discoveries show that characteristic primitive features persist much longer in the calvarium than in the mandible. This is a strict correlation or "law."

(4) The Swanscombe skull is not that of a primitive hominid, but is of modern human type.

(5) *Africanthropus njarasensis* is not the African form of either Sinanthropus or Pithecanthropus.

(6) Sinanthropus and Pithecanthropus are representatives of about the same evolutionary stage. Their differences are of the same kind and magnitude as modern racial differences. (Weidenreich calls the two forms by different *generic* names, although he regards them as belonging to one and the same *species!* Indeed, he doubts that there is a species difference between them and modern man. In defense of his terminology, he naively states that "I never imagined that anthropological names were tantamount to generic names or were considered as such by those familiar with the history of palaeoanthropology" (p. 246).)

(7) *Homo soloensis* (Ngandong skulls) represents the next evolutionary step in the line leading from Pithecanthropus to modern man. It less closely resembles Sinanthropus. While the equivalent of the European Neanderthalian, it is more primitive.

(8) The various Neanderthal forms—of which Rhodesian man is the most primitive—are intermediate between the Sinanthropus-Pithecanthropus group and modern man.

(9) Human evolution was not limited to one locality but occurred over a vast area comprising possibly the whole Old World. It took place over a long period of time—from Middle Tertiary to Upper Pleistocene—and was subject to interruptions. (Thus the author explains away the fact that modern human types of skulls unquestionably antedate many neanderthaloid remains.)

(10) One line of human evolution led from Pithecanthropus to *Homo soloensis* to the modern Australian aborigine. A second line led from Rhodesian man—who was closely related to *H. soloensis* and thus to Pithecanthropus—to Florisbad man to Boskop man to the modern South African. Sinanthropus gave rise to certain Mongolians. The European Neanderthals evolved—via the Skhūl group of Palestine—into Whites.

(11) The limb bones of all fossil hominids are perfectly human in character. This indicates that the adoption of erect posture far preceded the transformation of the skull.

(12) It is concluded that "... the organization of the human body, whether studied as a whole or in detail, is that of an anthropoid. No fact has become known which has the power to shake this statement" (p. 260). (The reviewer has read and repeatedly reread this statement in a vain attempt to decide just what the author means.)

(13) The limb bones of the anthropoid apes attained their special form and proportions at a very early period. Thus there must have been an early separation of hominids and anthropoid apes proper. Facts certainly suggest that the common primitive stem split into two final branches, one forming the apes, the other the hominids. This must have occurred before Dryopithecus and related forms were differentiated, at least (apparently) in the Lower Miocene.

(14) The Australopithecinae (Australopithecus, Plesianthropus, Paranthropus) seem to be closely related to the gorilla stem.

Weidenreich rigidly believes in the continuity of all fossil hominid forms. He will not admit the possibility that any represent collateral branches which became extinct without having given rise to more advanced types, although this point of view would reconcile the existing geological and anatomical evidence quite as well as does his polyphyletism. Many of his conclusions undoubtedly will be challenged, perhaps even demolished completely, yet his solid contribution of descriptive data remains. No other group of fossil human skulls has ever received more thorough and more competent treatment.

LABORATORY ANATOMY OF THE CAT.

By Ernest S. Booth. Illustrated by Carl Petterson. Walla Walla College, Washington. $1.50 (paper). 11 x 8½; 58; 1943.

This laboratory guide to the dissection of the cat is designed primarily for use in pre-medical and pre-nursing courses. The figures have been executed with simplicity and unusual clarity.

THE RELATION BETWEEN CENTRIOLE AND CENTROMERE IN ATYPICAL SPERMATOGENESIS OF VIVIPARID SNAILS. *Annals of the New York Academy of Science, Volume XLV, Article 1.*

By Arthur W. Pollister and Priscilla F. Pollister. New York Academy of Sciences, New York. 75 cents (paper). 9⅜ x 6½; 48 + 5 plates; 1943.

PHYSIOLOGY AND PATHOLOGY

AN OUTLINE OF GENERAL PHYSIOLOGY. *Second Edition, Revised.*

By L. V. Heilbrunn. W. B. Saunders Company, Philadelphia and London. $6.00. 9⅛ x 6; xii + 748; 1943.

Heilbrunn wrote this book because existing texts on general physiology did not meet the requirements of his teaching. In doing so, he produced one of the finer contributions to recent biological literature. The new, second edition has undergone extensive and thorough revision so as to include recent advances in the field. A number of topics—such as the vitamins of lower organisms, vitamins and oxidation, and the intracellular localization of enzymes—have been added. Newer technical procedures—such as electron microscopy and tracer elements—are discussed. There are about four thousand citations of the literature, of which over half are new.

This is more than a text-book, for it is so well documented that it serves as a source book for the many aspects of the subject. Furthermore, the author has avoided any tendency toward dogmatism and oversimplification, but, rather, has been at pains to emphasize existing gaps and uncertainties in our knowledge. The result is a book that can be read with profit by all who term themselves biologists.

THE PERMEABILITY OF NATURAL MEMBRANES.

By Hugh Davson and James Frederic Danielli. With a Foreword by E. Newton Harvey. Cambridge: at the University Press; The Macmillan Company, New York. 25s. 8⅜ x 5⅝; x + 361; 1943.

No subject is more fundamental to our understanding of living systems than a study of the movement and control of substances entering and leaving the individual cells. The study of permeability has been advancing very rapidly, and although the recent work has come in for much discussion and has been the topic for a number of symposia, no general books on the subject have appeared for many years. There is, therefore, a definite need for a volume such as this.

In recent years the study of cell permeability has become truly quantitative, and the authors of this book place considerable emphasis upon this point. Most of the book is devoted to experimental results, with only enough discussion of theory to present them in a coherent manner. However, the chapter on "Impedence and Potential Measurements and Permeability" contains a more complete discussion of the theory of membrane potentials, and the last chapter of the book deals exclusively with the theories of cell permeability.

All of the discussions are based upon the assumption that the permeability characteristics of a given cell are determined largely or exclusively by a very thin "plasma membrane." Recent work showing the importance of contact exchange and surface migration of ions in cell penetration has been omitted. Although much remains to be done in this field, these exchange phenomena serve to account for the rapid transfer of ions shown by isotope studies, and point to the participation of a much thicker protoplasmic layer than the plasma membrane usually postulated. It is very unfortunate that these advances were not fully discussed.

Many of the experiments presented do not allow a clear-cut interpretation of their significance, but an effort has been made to evaluate critically both the methods employed and the results obtained. The discussions do not cover a given subject exhaustively, but are based on work selected by the authors as of primary importance. The bibliographies accompanying each chapter are also selected and do not attempt to review completely the literature on any given subject. The book has a subject, but not an author index.

On the whole, the authors have handled a difficult subject in an admirable manner.

THE SOURCES OF LIFE.

By Serge Voronoff. Bruce Humphries, Boston. $3.50. 9⅛ x 6; 236; 1943.

The wide spread publicity that followed the spectacular result of Dr. Voronoff's gland grafting work made this book inevitable. Voronoff was not the first surgeon to attempt gland grafting, but he was the first to achieve any considerable success. The earlier attempts were mostly failures owing to the resorption of the glands.

Dr. Voronoff's success was due to three discoveries made by experimentation on mammals other than man. First, such grafts can succeed only when made between closely related species. In the case of man, only the glands of higher apes can be used. Second, the body which receives the graft must be prepared about 24 hours before the operation by being stimulated to produce new capillaries. Unless a connection can be made between the circulatory system and the gland the latter will die of malnutrition. Third,

glands are very sensitive to changes of temperature and the implantation must be made in a location having a temperature nearly equal to that from which the gland was taken.

The most striking of Dr. Voronoff's accomplishments is the restoration of a congenital idiot to a state of normal mentality. The "before and after" photographs of the subject are most impressive. This miracle was accomplished by grafting a piece of thyroid tissue. The thyroid can be divided so that the donor suffers no impairment of mentality. However, congenital idiocy is definitely an abnormal condition and those who exhibit this trait constitute a very small proportion of the population. On the other hand, senility is a normal condition that confronts all of those who live long enough, and the hormones which prevent it come from the genital glands, which cannot be divided like the thyroid, but which must be transplanted in their entirety. Human glands therefore cannot be used, and recourse must be had to those of the higher apes.

The human population of the world today greatly outnumbers that of all species of apes taken together. Consequently, if all senescent old men demanded gland grafts, the result could only be extinction of the apes, with resulting loss of hope for the future. To anticipate such a situation Dr. Voronoff suggests the domestication of the apes. Domestic cattle, he quite justly observes, are more numerous than wild cattle; if we can domesticate cattle for the use of their flesh as food, why can we not domesticate the apes for surgical purposes? This is a radical idea, but Voronoff is a thorough revolutionist and does not hesitate to throw a "monkey ranch" into the established social machinery. The purpose of his book is to appeal for support of this idea. It is frankly propagandistic and is addressed to the laity, not to the medical profession. Probably there is no statement in it of any fact that has not been known to the medical profession for at least one generation.

In this book the author crusades on behalf of yet another cause. The opposition of humane societies to vivisection, as it has only too frequently been practiced in the past, is well known. Dr. Voronoff is whole-heartedly in sympathy with the humane societies in their efforts to suppress cruelty to animals and takes pride in the fact that in his laboratory all operations are performed under full anesthesia, and that the convalescent ape receives the same care that would be given a human being. The gelding of stallions for commercial purposes is a different proposition, and the description of a gelding which Dr. Voronoff witnessed is enough to nauseate any right thinking person. Certainly practices of this sort should be suppressed by law, the more stringent the law the better; Dr. Voronoff's protest will probably win for him the confidence of many potential clients who might be inclined to distrust an operator who was merely a clever surgeon and nothing more.

One statement in the book is not likely to meet with universal acceptance. This is, that if grafts are performed on several successive generations the improvement will be permanent, and no further grafts will be required to maintain it. Apparently Voronoff accepts the doctrine of the inheritance of acquired characteristics.

Two questions are likely to come to mind when gland grafting is contemplated. The first is: Is it possible for a man grafted with monkey gonads to have simian progeny? The answer is most emphatically no. The gametes are discharged through the genital ducts, and by tying the grafted duct the gametes are prevented from leaving the grafted gonads. (The hormones do not traverse the ducts, but pass directly from the glands to the capillaries.) The second is: Will gland grafting on a large scale tend to lengthen the span of life? Again the answer is no. The duration of an individual life may be increased, because the grafted individual may acquire resistance to diseases that ordinarily take a large toll of human life, but natural death from the running down of the living machinery of the human body will come at the same age in both the grafted and the ungrafted. The old man who submits to a grafting operation cannot add to the number of his days, but he will renew his strength like the eagle and preserve his youthful vitality to his deathbed, and he shall see his sons and his son's sons, even unto the fourth generation, and they shall call him "glandpa."

FOOD AND PLANNING.

By J. R. Marrack, with a Preface by Sir John Boyd Orr. Victor Gollancz, Ltd., London. 15s. 7¾ x 5; 285; 1943.

THE PROBLEM OF CHANGING FOOD HABITS. *Bulletin of the National Research Council, Number 108. A Collection of Twenty-four Papers.*

Report of the Committee on Food Habits, 1941–1943. National Research Council, Washington, D. C. 9¾ x 6¾; 177; 1943.

These books are extremely timely. In days of meat shortages and ration stamps everybody is interested in food, but most of the available literature is not characterized by either clarity of expression or lucidity of thought. The present works are exceptions to this general rule.

As an illustration of the meticulous care which Dr. Marrack has taken to make his book really readable, it may be pointed out that he has resolved the paradox that has baffled so many radio dietitians and armchair experts—why is a man's daily caloric output apparently so much greater than his intake? The

explanation is that the nutritional calorie, in terms of which the intake is expressed, is equal to one thousand calories of the physicist, which are used for the output. The author suggests that the resulting confusion might be obviated by the use of either term, megacalorie or kilocalorie, for the larger unit, but if the experts refuse to adopt this sensible suggestion, the least they can do is to spell it with a capital initial.

The author has assembled a great deal of data about nutrition, such as the classification of food stuffs, the way in which they are utilized in metabolism, some for building body structures, others for conversion into energy, and still others for the prevention of deficiency diseases. Each one of the twenty-odd vitamins now known, with the specific condition for which each is a preventative, is described in detail. (Incidentally, the difference in meaning between vitamin and vitamine is explained; some writers have implied that there is no difference.) The book contains page after page of tabulations of food analysis from various origins—in fact, practically all the experimental work ever done on nutrition is displayed in concise and systematic form.

Different peoples are characterized by the kind of food they eat—we need think only of chow mein, chili con carne, or Yorkshire pudding to realize the validity of the slogan of a well known breakfast cereal, "Tell me what you eat and I will tell you what you are." In times of war there are of necessity fluctuations in diet with consequent changes in national health. Numerous statistics are available that deal with the public health of the leading nations on both sides in the present conflict during the twentieth century, and all of these are carefully analyzed in an unprejudiced manner. All told, this book by Marrack is the best general presentation of modern knowledge of nutrition that the reviewer has as yet come across.

The book by the national research council is of a somewhat different nature. It is a symposium by fourteen different writers, all of whom write on a highly specialized phase of the subject. While *Food and Planning*, although obviously compiled for British perusal, is of such a generalized nature that it can be read with profit and interest by any one, *The Problem of Changing Food Habits* is a highly technical and microscopic examination of a small part of the field covered by the former work. It is intended for the specialist in public health in the United States, and is not likely to have much appeal outside this narrow circle. It is the fruit of an investigation undertaken as a national defense project, and the author of the preface implies that it is frankly propagandistic. A comparison between the two books shows very clearly the difference between the British and the American mind—a difference which is all in favor of the British.

There is one detail in which the British writer successfully defies the imagination of the reviewer. Among the foodstuffs analyzed for protein, fat, and carbohydrate content appear "boiled Swedes." Can it be possible that the food shortage in Britain is so acute that our cousins across the pond have been reduced to anthropophagy? The feelings of the reviewer when this shocking item caught his eye can be appreciated only by the Englishman who, when travelling in the States, encountered for the first time baked Indian pudding.

ROSE'S FOUNDATIONS OF NUTRITION. *Fourth Edition. Revised by Grace Macleod and Clara Mae Taylor. The Macmillan Company, New York.* $3.75. 8¾ x 5¾; xi + 594; 1944.

This book is written for those who wish to live more intelligently. An effort has been made to present within a small space some of the fundamental principles of human nutrition in terms which call for no highly specialized training in those natural sciences upon which the science of nutrition rests. The selection of topics and the relative amount of space devoted to each are based on the authors' wide experience in presenting the subject of nutrition to those beginners whose object is to be well informed as to the significance of food in daily life. Each essential factor in an adequate diet is discussed in detail, with many references to animal experiments which help to make clear the reasons why this essential factor must have a place in the daily program. The foods which serve best as sources of these essentials have been indicated, and a very practical method of comparing foods, on the basis of the amount of a given dietary essential to be obtained from each in relation to the total day's requirement, is set forth. The reading references at the end of each chapter are noteworthy for their availability and clearness. Throughout the text some references to original investigations have been included as footnotes, for the sake of those who wish to get a little more of the experimental point of view.

Those familiar with the earlier editions of the book will note a considerable amount of reorganization in this one. The chapters on the vitamins, on energy, protein, water, and the minerals, and on dietary planning have either been completely rewritten in the light of newer knowledge, or they have been extensively reorganized and rearranged. Several new tables have been added to the extensive list of those already included. The figures for the construction of adequate dietaries on the basis of the percentage distribution of calories among the different food groups have been brought together in tables for different age groups in the appendix. There is a complete and well-arranged general index. Here is a book that has proved itself completely ever since the first edition was published in 1927. It can be heartily recommended to dietitian,

nurse, clinician, and layman alike, and should enjoy a wide circulation among all those wishing to be well-informed on this all-important subject.

NUTRITION IN HEALTH AND DISEASE. *Ninth Edition, Revised.*

By Lenna F. Cooper, Edith M. Barber and Helen S. Mitchell. J. B. Lippincott Company, Philadelphia and London. $3.50. 8 x 5¾; xiv + 716; 1943.

Long association with medical institutions has led the authors to believe that the present status of the subject of dietetics demands a somewhat different emphasis from that formerly placed upon it. The continuing success of this textbook has demonstrated the correctness of the authors' convictions. Here is a single volume which may serve as a handbook on the subjects of nutrition and diet in disease, two subjects so intimately and vitally connected as to necessitate their being inseparably united in the mind of the nurse, for whom this text is primarily intended. The book presents the newer ideas in both the principles of nutrition and the practice of dietetics, based upon the most recent experimentation and study as well as upon the established knowledge of earlier research findings. It includes the prevailing practices of leading physicians in the field of nutrition as applied to health and disease. Wherever physicians differ greatly in their dietary practices, the authors have endeavored to present the consensus of opinion, where such exists, or the prevailing regimens, with the scientific principles involved. Throughout the book the preventive and remedial aspects of nutrition have been emphasized. Not only the needs of the bedside nurse have been kept in mind, but also the problems of the public health nurse, who must cope with poverty, racial preferences, and established food habits as complicating factors. The present edition, like the two previous ones, is arranged to conform closely to *A Curriculum Guide for Schools of Nursing*, published by the National League of Nursing Education.

The contents of the book are arranged to cover several nursing courses. There are seven principal divisions, as follows: principles of nutrition, diet in disease, feeding of mother and child, nutrition and health service, food selection and cookery, cooking for the sick and the convalescent, and tabular material and special tests. The excellent and well-chosen illustrations, including a number of color plates, are a very distinct feature of the text and of genuine value to the student or lay reader. The chapter on "Food and Nutrition Problems in Wartime" is especially timely and helpful. A new feature of the ninth edition is the glossary which gives a concise definition of the technical words appearing in the text and their pronunciation. There is also a list of reference books and scientific journals and a complete index. Nurses, teachers of nurses, dietitians, homemakers, and all those whose responsibilities include planning meals and buying and preparing food will profit by the use of this fine text.

APPLIED DIETETICS. *The Planning and Teaching of Normal and Therapeutic Diets. Second Edition.*

By Frances Stern. The Williams and Wilkins Company, Baltimore. $4.00. 10 x 6¾; xx + 265; 1943.

The material presented herein is based on methods developed and constantly refined in the Food Clinic of the Boston Dispensary, the pioneer clinic of its kind, organized 26 years ago. This second edition has been enlarged and improved to meet changing needs, and in order to include the results of the accelerated research in nutrition and their applications to modern dietetics. Normal diet is considered in relation to normal physiology, whereas the therapeutic diet is conceived as a deviation from the normal, calling for an increase or decrease in the amount of a food constituent, or the omission or change in consistency of foods as used in the normal diet. The bulk of the information is presented in tabular form. There are 57 coordinated tables to simplify the computation of the diet, serving for reference and interpretation, much as do the tables on which an engineer relies. Typical menus and diets are set down in detail in 20 pairs of full page tables. Tabular summaries provide quick surveys over the material dealt with in various sections of the book. Dietary outlines, concise and complete, greatly aid and simplify the dietary treatment of such conditions and diseases as food allergy, constipation, peptic ulcer, obesity, diabetes, liver disorders, nephritis, and the vitamin deficiencies. This book is somewhat unique because it tends to promote a closer interdependence of physician, dietitian, social worker, nurse, and public health worker, and because the methods described for planning and teaching make it unnecessary to memorize formulas. The author's presentation emphasizes the relation of personality to food: environmental factors that influence the effectiveness of the diet, food preferences of different nationalities, and education of the patient on the normal and therapeutic diet.

This excellent book is highly recommended for teachers of dietetics, and will be a most useful reference book for physicians, hospital and clinic dietitians, public health workers, nurses, and all others who have a special interest in this field.

NUTRITION OF THE DOG.

By Clive M. McCay. Comstock Publishing Company, Ithaca. $1.50. 9 x 5¾; v + 140; 1943.

This book will find favor not only with the pet owne

but also with the kennel breeder, the veterinary, and the research worker on nutrition. In a simple yet thoroughly authoritative manner, the writer explains the carbohydrate, fat, protein, and mineral requirements of the dog. The topic of vitamins is well presented; many dog owners will be surprised to learn that these animals do not need vitamin C, since it is apparently synthesized within the dog's body. The subject of dog feed is discussed in great detail and contains much useful information, for the writer is a consultant in the preparation of dog foods. All the data offered are based on personal research or on information culled from the literature; in the latter case, citations are given for those desiring further information. The role dogs have historically played in research on human nutrition is described in the introduction and interspersed throughout the text. This valuable contribution, at so reasonable a price, should induce every dogowner to own it.

CIVILIZATION AND DISEASE.

By Henry E. Sigerist. Cornell University Press, Ithaca. $3.75. 9 x 6; xi + 255; 1943.

Dr. Sigerist's new book is based on a series of six Messenger lectures delivered at Cornell University in November and December, 1940. In these Dr. Sigerist examines the impact of every single element of civilization on disease, from the most elementary and humble, such as food, clothing, housing, and occupation, to the most noble and complex, such as music, religion, science, and philosophy. On the other hand, he shows the formative influence of disease on civilization, its history, its laws, its art, its literature. He illustrates from his encyclopedic knowledge of history how civilization deals with disease and fights disease. The tremendous advance of civilization in this struggle, during a relatively short period, inspires Dr. Sigerist with an unlimited faith in future progress.

As can be seen from this short resumé, the book covers an extremely large field. Each of the twelve chapters could easily have been the subject of a whole volume. It is therefore very difficult to argue what else should have been mentioned, and it is rather surprising and a sign of a judicious choice of materials that the reader actually almost never has any feeling of omission. Nevertheless, the reviewer feels that Balzac rather than Victor Hugo, Flaubert, or the Goncourts should be regarded as the true father of the "scientific" novel; and that the fact that Flaubert and Proust were the sons of outstanding clinicians is significant enough in this context to be mentioned. The reviewer does not agree with the author's wholesale condemnation of the romantic medical school, which left some important clues and some astonishing "premonitions" to posterity.

Some of the problems of the book have already been touched upon by Dr. Sigerist in earlier publications, but the bulk of the book consists of highly interesting, new and original material. Although erected on the same philosophical foundations as the author's earlier books and using historical analysis always in close connection with our present and future, *Civilization and Disease* seems less liable to provoke controversy. Although a very learned and thoughtful treatise, the book is by no means written only for the specialist, but is popular in the best sense of the word and easily intelligible to the educated layman, not only because of its fascinating subject but also because of its excellent craftsmanship. It still retains the lively and personal diction of the original lectures. A wealth of characteristic, carefully chosen illustrations enhance its value.

HUMAN CONSTITUTION IN CLINICAL MEDICINE.

By George Draper, C. W. Dupertuis and J. L. Caughey, Jr. Paul B. Hoeber, Inc., New York. $4.00. 9¼ x 6; xi + 273; 1944.

"The purpose of this book is to discuss with medical students the fact that there is an essential relationship between each individual person and the disease which at any moment he or she may suffer. It is therefore primarily an essay concerned with clinical medicine, yet one which deals especially with the nature of the man within the patient." Toward this end the authors have utilized morphological, psychological, immunological, and physiological characters to elucidate the constitutional factors in disease. Their theory of constitution in relation to disease originated from observations made during an epidemic of infantile paralysis in 1916 when it was discovered that children susceptible to paralysis showed some consistent differences in constitution from children who had not succumbed to the trouble.

Illness is best studied from the standpoint of (1) the human subject, (2) the disease process, and (3) the specific environmental stress. The constitutional studies are an illumination of this first item. There are chapters on history-taking, which stress the importance of spontaneity in method rather than devotion to question and answer methods; on genetics and clinical medicine, with excellent studies showing the hereditary factor in disease; on growth, development, decline, and death; on the mosaic of androgyny; on problems of observation, correlation, and interpretation; on anthropometry; on somatotypes; and on constitutional physiology and the clinical use of constitutional studies. In this last named chapter the authors illustrate the clinical application of constitutional studies, including personality factors, in poliomyelitis, diabetes, and peptic ulcer. There are two final chapters considering the unity of the organism and embodying conclusions concerning the entire

problem. The authors state that "There is no final formula, however, which can be generally applied in this matter of understanding the man within the patient. We believe that certain technical methods can be efficiently brought to the hard problem of appraising the nature of a human being. Certain of these procedures have been set down in the foregoing pages. They have dealt with morphology, physiology, immunity and emotion. . . . The final technique of the initial approach to the patient must be wrought from special qualities within the personality of the doctor, and through his cultivated talents. The common source from which each physician must draw his raw materials is mankind itself." There is an extensive bibliography.

The book is well written and presents an excellent statement of the modern viewpoint of constitution in relation to clinical medicine.

ON THE INFLUENCE OF TRADES, PROFESSIONS, AND OCCUPATIONS IN THE UNITED STATES, IN THE PRODUCTION OF DISEASE. *Reprinted from Transactions of the Medical Society of the State of New York. Vol. III, Albany, 1837.*

By Benjamin W. McCready, M.D. 1837. With an Introductory Essay by Genevieve Miller. The Johns Hopkins University Press, Baltimore. $1.75. 7¾ x 5½; 129; 1943.

This little book is Volume IV in the Fourth Series: Bibliotheca Medica Americana, representing the publications of the Institute of the History of Medicine of the Johns Hopkins University.

For those who are interested in or are engaged in industrial hygiene, medicine, and health work, this book represents one of the most important volumes in the history of the development of industrial and occupational medicine in this country. The original material was written as an essay in a contest sponsored by the Medical Society of the State of New York in 1835. Dr. McCready wrote the book at the age of 23, only two years after he had been graduated from the College of Physicians and Surgeons, having meanwhile served a term as house physician at the New York Hospital. The author was considerably influenced by a book published in England in 1831 by Dr. C. Turner Thackrah, which was the second all-inclusive monograph on occupational diseases, following Ramazzini's immortal work in 1700. Included as chapter headings in the McCready book are those with reference to agriculture, laborers, housing, seamen, factory operatives, artisans, professional men, literary men, and the general causes of poor health.

This essay represents a remarkably mature and realistic approach to the problem of occupational diseases as it was in the early 19th century in America. Particularly foresighted was the author with respect to health education for the masses, the principles of which are not even yet extensively and generally applied in industrial groups. References are given as footnotes. There is no index. The book deserves the attention and should provoke the reflection of industrial physicians, physiological hygienists, and all others who would understand the economic and social background of American industry.

MEDICINE AND THE WAR.

Edited by William H. Taliaferro. The University of Chicago Press, Chicago. $2.00. 8 x 5⅛; vii + 193; 1943.

In few fields of man's endeavor so much as in that of medicine does war so evidently leave behind it some things of worth in exchange for the supreme values it steals from civilization. Need, patriotism, skill, and humane desire join with the abundance of sick and wounded men in days of armed strife to bring progress in medical science and practice. Fewer men, in proportion to the numbers engaged in fighting, are dying from wounds in this war than in World War I or in any previous war in recorded history. Every day medical miracles take place on battle fronts, in isolated jungle camps, in every spot in the world where armed forces are located. The new sulfa drugs and the modern treatment of shock have been of major importance in the saving of lives. As a result of modern psychotherapy, it is estimated that 70–80 per cent of the battle-zone casualties due to psychiatric disorders can be returned to duty. These are only a few of the astounding strides that medicine is making in this war.

This little volume describes in nontechnical language some of the important work that is being done today in connection with the medical care of the armed forces. After a brief review of the history of war medicine, the topics dealt with include: food, the basic fuel for the human part of the war machine; chemotherapy, the wonder science of modern medicine; malaria, the most important infectious disease in the present conflict; the dissemination of diseases and disease-carrying insects by modern rapid transportation; aviation medicine; brain injuries; psychiatric disorders; surgical shock, which is the common danger in all types of severe wounds and makes the establishment of blood banks so urgent; and chemical warfare. In addition, some unsolved problems are mentioned and by their nature indicate why research is assuming such an important position in this war. The authors are all members of the faculty of the Division of the Biological Sciences of the University of Chicago. Bibliographies are given at the ends of most of the chapters and there is a good index provided. This book can be highly and heartily recommended to all those, scientists and laymen alike, who wish to know more about the increasingly important and amazing role that the

art and science of medicine has assumed in modern warfare.

ARE YOU ALLERGIC?

By Jessamine Hilliard and Charles C. Coghlan. M. Barrows and Company, Inc., New York. $2.50. $7\frac{1}{8}$ x $5\frac{3}{8}$; vi + 248; 1943.

The material herein included is rather timely for everyone. Most people are allergy-conscious and while this volume is not intended as an outline for the treatment of allergy, enough knowledge can be obtained from it to enable many people to detect their sensitivity by a process of trial and error. It will help the reader understand his own strange sneezing, his skin "infections," the hay fever, hives, watery eyes, restlessness, and more serious ills which beset him and which may be caused by the bed on which he sleeps, the food he eats, the place in which he works, the clothes he wears, his wife's hair combings, his pet dog or cat or canary. The authors have presented in an interesting, readable style hundreds of examples of allergy. They include men and women in the higher income levels, with seemingly every advantage which money and the best of medical care can provide; they embrace workers in factories and mills, in the field and the home; they extend to the allergies of children, from the youngest baby to school and teen-age youngsters. These allergies are described in detail so that the average person may recognize the sufferings of some member of his family or of friends, and know them at least for what they really are.

While the authors have kept this book free of heavy medical terminology, so that practically everyone can read and understand it and be helped, yet by its thoroughness in covering the scope of the entire field of allergy, it constitutes a valuable resumé for physicians, nurses and other specialists. Included is much material on the research methods of the past and present. Incidentally, the physician or public health worker who has not specialized in allergy and who is only beginning to apply new findings regarding it will find this book especially helpful. An extensive bibliography and an index are appended to the volume. Lay reader and scientist alike should find much of interest and value in this well-written book.

HEALTH AND HYGIENE. *A Comprehensive Study of Disease Prevention and Health Promotion.*

By Lloyd Ackerman. Jaques Cattell Press, Lancaster. $5.00. $9\frac{1}{4}$ x $6\frac{1}{4}$; xii + 895; 1943.

To a population battered incessantly by the drug concerns advertising patent medicines for achieving health, this latest in the series of "Humanizing Science Books" should have an instant appeal. And to college hygiene teachers, as well as to the freshmen who take their courses, an up-to-date book which copes with the basic problems of the field, however controversial, in a comprehensive and objective way, should mean a new stimulus to the whole subject of personal health and social responsibilities in health. The author "has attempted to provide a book that will appeal to mature, inquiring minds in all circles: nonscholastic as well as scholastic, lay as well as professional, and legal, political, engineering, social service, journalistic, pedagogical, and religious as well as medical." In the opinion of this reviewer, he has been remarkably successful in this attempt.

In the preliminary discussion of the hygienic concept, the author recognizes that it embraces both personal endeavor and organized effort on the part of society. This book is mainly concerned with personal hygiene, and although some discussion is given to professional health services, social (not to be confused with socialized) medicine, with its modern views of regional health centers and so on, is not part of the subject matter of the book.

The book is divided into ten main parts, with several chapters in each. The main subjects include: Introduction (which discusses fundamental concepts and a statistical survey of the health problem); Evolution of Health Concepts and Health Practices; Evaluation and Importance of Health Concepts and Practices; Parasitism and Hypersensitiveness; Hygiene of the Mouth; Hygiene of Nutrition; Hygiene of the Emotions and the Intellect; the Hygiene of Mating; Exogenous Poisons; and Physical Agents and Their Relations to Health. These subjects are developed from the point of view of the basic knowledge with regard to them. The evidence on the many controversial issues is presented, but the discussion is always distinguished by objective evaluation and freedom from dogma and emotionalism. A bibliography accompanies every chapter.

In order to give some idea of the breadth of view with which the subject matter is presented, it may be well to give a brief discussion of one section. The third part, on the evaluation of health concepts, opens with a discussion of the complexity of evaluation in this field, first, because of the adaptability of man, and the difficulty of knowing what would have happened in the absence of the hygienic or therapeutic aid to be evaluated, and second, because of the influence of the psychology of the investigator. There follows a discussion of the importance of controlled experiments and the pitfalls one may encounter in getting a control and in interpreting the results. This is followed by a discussion of the contribution of demographic studies to our knowledge of health practices, so that the epidemiological approach to health studies is introduced. Thus the student is presented with a bird's-eye view of the sources of knowledge and scientific methods, and with cautions concerning critical

evaluation of the evidence. In the sections on specific problems of hygiene, the type of sound judgment advocated in this part is characteristically used by the author in evaluating the evidence presented.

The book will perform a real service for any adult wanting to learn the historical background of our health practices, the present status of our knowledge, and the physiological and psychological factors important in achieving positive health.

THE FUNDAMENTALS OF PERSONAL HYGIENE *Including Their Practical Application to Healthful Living. Fourth Edition, Revised.*

By Walter W. Krueger. W. B. Saunders Company, Philadelphia and London. $1.75. 7¾ x 5¼; xi + 315; 1944.

This text, intended for high-school levels, provides the fundamentals of hygiene for a healthy and wholesome life. Proper nutrition, the significance of over- and underweight, the value of exercise and posture, care of the feet and skin, correct clothing, the effects of mental attitudes, recreation, sex, and preventive measures against disease are some of the topics intelligently discussed. Quacks, patent medicines, harmful drugs, and false advertising claims are properly evaluated and their dangers and weaknesses pointed out. Following each chapter is a series of questions for oral discussion and topics for written reports, as well as a selected bibliography. The volume is illustrated with numerous charts, diagrams, and photographs. Some of the latter are conspicuously carry-overs from previous editions and tend to give the impression that the text may also be somewhat out of date. This is the more unfortunate, as the text has been completely revised and brought into line with the latest facts and findings of medicine and physiology.

CLINICAL TROPICAL MEDICINE.

Edited by Taylor Bercovitz, with a Foreword by Wilbur A. Sawyer. Paul B. Hoeber, Inc., New York and London. $14.00. 10 x 7; xvii + 957; 1944.

Quoting from the foreword of Dr. Wilbur A. Sawyer, "The rank and file of American physicians and medical students have until now felt no urge to familiarize themselves with exotic and tropical diseases and have had little encouragement or opportunity to do so. War has suddenly brought a departure from this medical isolationism. There is now a pressing demand for authoritative and practical instruction in the treatment and prevention of the diseases of the warm countries. Medical men who have seldom seen malaria or dysentery and have never encountered yellow fever or typhus are now facing the prospect of caring for troops and civilian workers in the tropics of America, Africa, and the Far East."

In this large volume, Dr. Bercovitz has attempted to assemble for the medical man the information necessary to cope with his new problems resulting from the present world conflict. He has included all types of tropical diseases; those produced by infectious agents (viruses, rickettsiae, spirochetes, bacteria, protozoa, and worms), by poor nutrition, by heat, or by poisonous snakes and insects. Due to the many fields concerned with tropical medicine, the author has solicited the aid of a distinguished advisory board composed of Dr. W. W. Cort, Col. Charles F. Craig, and Col. Edward B. Vedder. In addition to this assistance, twenty-six outstanding authorities contributed to the volume by writing chapters on their specialized fields. Of the seventy-three chapters, seventeen were written by Dr. Bercovitz and the remainder by the other contributors.

Although major emphasis is placed on the clinical phases of the diseases, information on epidemiology, prevention, and laboratory diagnosis is also amply presented. If the reader is familiar with the subject of a particular chapter, he may find that some of the more recent details have not been included. These omissions can perhaps be explained by the following statement from the author's preface: "This volume has been planned to give the medical student a definite picture of tropical diseases, their symptomatology, pathology, and the most authentic and effective therapeutic and preventive measures, before he plunges into specialized monographs and controversial articles on the manifold aspects of tropical medicine."

The text material is well illustrated with numerous plates and figures. Here again the author has followed a wise policy of presenting the typical rather than those rare manifestations of the diseases which too often grossly exaggerate the importance of a particular condition. At the end of each chapter, a list of references is presented; and at the end of the book there is a complete index.

THE JOHNS HOPKINS HOSPITAL AND THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE. *A Chronicle. Volume I. Early Years, 1867–1893.*

By Alan M. Chesney, with a Foreword by William H. Howell. The Johns Hopkins Press, Baltimore. $3.00. 9¼ x 6; xviii + 318; 1943.

The first volume of Dean Chesney's history of the Johns Hopkins Hospital and Medical School was a most timely gift for the School's Fiftieth Anniversary. This first volume takes us from the incorporation of the hospital in 1867 up to the opening of the school in 1893. We become acquainted with the founder, the trustees of the hospital, many of them members of the Society of Friends like Johns Hopkins himself, and with the first president of the Board of Trustees, Francis T. King, whose great merits are for the first time emphasized by Dr. Chesney. We observe the

important role of J. S. Billings and D. C. Gilman in the making of the hospital. We are informed of the financial difficulties, which protracted over such a long period the building of the hospital and the opening of the school. We see the beginnings of teaching by the physiologist H. N. Martin, who himself died too early to participate in more than the "prehistory" of the school. We learn that the trustees were in favor of the full-time system already in 1884, and that the resident system originated in the hospital. Shortly before and with the opening of the hospital in 1889, the "big four," Osler, Halsted, Kelly, and Welch enter the scene—soon to be surrounded by men like H. M. Hurd, W. S. Thayer, J. W. Williams, G. H. F. Nuttall, J. Hewetson, and later F. P. Mall, J. J. Abel, W. H. Howell, and all those other men who were destined to leave their mark upon American medicine, too numerous even to be listed here but all characterized by Dr. Chesney. The episode of the "Women's Fund Committee" and the gift of Miss M. E. Garrett which eventually made possible the opening of the medical school, is given in detail and illustrated by many documents. There is something extremely charming and fascinating in these early years of the hospital and of the preparation of the medical school where a group of young enthusiasts, most of them still in their thirties, set out to build a new medical world in the "New World."

The story shows that the history of hospital and medical school are so closely interwoven that indeed they hardly could have been treated separately. The form of a chronicle chosen by the author seems to be best adapted to events which are still rather close to the present. Nobody could be better prepared to write such a chronicle than Dean Chesney, who has at his disposal not only the long and rich personal experience of a life-long connection with Hopkins, but ex officio documents otherwise perhaps inaccessible or likely to be overlooked. The reader will greatly appreciate not only the first-hand publication of such documents, but also that all the essential facts, until now so widely dispersed in biographies, autobiographies, articles, and other publications, have been eventually concentrated and synthesized by the author. The book will be most welcome to all who are interested in the history of American medicine and American education.

THE HARVEY CUSHING COLLECTION OF BOOKS AND MANUSCRIPTS.

Issued under the Auspices of the Historical Library, Yale Medical Library. Schuman's, New York. $8.50. 11 x 7⅞; xvi + 205; 1943.

The Harvey Cushing Collection is one of the pillars of that great treasury of old medical books, the Historical Library of the Yale Medical Library. The publication of a short title catalogue of Harvey Cushing's books, compiled by the late H. H. Schaltenbrand, Miss M. Brinton, and Mrs. H. T. Perkins is therefore most welcome to all working or interested in medical history and the history of science. The most important and most complete parts of Cushing's library were those on early anatomy (Vesalius) and surgery. But as the catalogue shows, it also contained a surprising number of valuable books, especially of the 17th and 18th century, covering other fields of medicine and science. Whether the inclusion in the catalogue of twentieth century books and especially of reprints, accumulated in a rather haphazard way, was particularly useful or necessary, may be doubted.

PAPERS OF A PIONEER.

By Sir Pendrill Varrier-Jones. Collected by Peter Fraser. Preface by Lord Horder and Introduction by Sir Humphry Davy Rolleston. Hutchinson and Company, Ltd., London and New York. 6s. 7¼ x 4⅞; 107; 1943.

In this little book Mr. Peter Frazer, for long years the collaborator of Sir Pendrill Varrier Jones, has collected and arranged the most significant utterances of the late, great English sanitarian. Sir Pendrill not only clearly saw that tuberculosis is a sociological and economic as well as a medical and psychological problem; but in founding Papworth, a village-settlement for the "after-cure" of tuberculosis he set a milestone in tuberculosis treatment, admired and imitated all over the world. The selections, taken from papers published between 1915 and 1941, make very good reading and can be highly recommended to everyone interested in tuberculosis or public health.

THE JEWS AND MEDICINE: *Essays. In Two Volumes. By Harry Friedenwald. The Johns Hopkins Press, Baltimore.* $7.50. 9¼ x 6¼; Vol. I, xxiv + 390; Vol. II, vii + 391–817; 1944.

In these essays Dr. Harry Friedenwald, professor emeritus of ophthalmology at the University of Maryland, himself member of a Jewish medical "dynasty" and a famous book collector (more about the background of the author is told us in Dr. Sigerist's substantial preface) gives us the fruit of almost fifty years of historical research. The relations of the Jews to medicine offer indeed material enough for more than one life-span of study. Medicine being during centuries one of the few creative activities open to Jews, they have amply used this opportunity and have been faithful to a great tradition in spite of all difficulties up to this day.

Although dealing occasionally with all aspects of the problem, Dr. Friedenwald has wisely concentrated his efforts mainly on two periods of Jewish medical history less known and perhaps more interesting than

others: The Middle Ages and the Renaissance. While Mosaic medicine has somewhat the character of a tribal medicine, and while with the great Jewish Doctors of the 19th century the fact of their being Jews appears rather unspecific and incidental, the Jewish doctors of the Middle Ages and Renaissance form an important part of Western medical history and are at the same time still a living part of Jewish religious and literary tradition. Together with the Arabs, as their coworkers, their translators into Latin, Spanish and other European tongues, spreading Hebrew translations of Arab works wherever Jewish doctors practice, the Jews truly enter the great western medical tradition which reaches down from Hippocrates to our days.

Dr. Friedenwald has attacked his problem from all sides and in every possible form: giving biographical sketches from Maimonides to Zacutus Lusitanus, Amatus Lusitanus, Garcia da Orta and Jean Astruc, writing extensive chronicles of the Jewish physicians in Spain, Portugal, Italy, Southern France, and after their expulsion from these countries at the end of the fifteenth century. Dr. Friedenwald has made cross sections: showing these Jewish physicians as book lovers, apologists, satirists, ophthalmologists, at the universities; in East India; showing their attitude towards witchcraft. He has composed interesting bibliographies, analysed their case histories, etc.

One may regret some errors of detail, such as a repetition of the Juan Lopez de Vega legend, who did not bring the cinchona bark to Europe because he never returned from Peru, and one may judge the bibliography of diseases of the Jews too sketchy, but the fundamental fact is that throughout his book the author has maintained the highest standards of scholarship, a fact unfortunately not general in medico-historical writing. In spite of the incredible sufferings which this book is obliged to report, it never becomes cheaply melodramatic. The history of the medical theory and practice of the Jewish physicians is an important illustration of the medicine of their time in general. The varying ways in which society treated them illustrates the ups and downs of progressive thought in society during the last one thousand years. Dr. Friedenwald's book is a most valuable contribution to the history of medicine and civilization.

PSYCHOLOGY AND BEHAVIOR

PRINCIPLES OF BEHAVIOR: *An Introduction to Behavior Theory.*

By Clark L. Hull. D. Appleton-Century Company, New York and London. $4.00. 8¼ x 5⅝; vii + 422; 1943.

Every serious student of psychology will want to read Professor Hull's new book, if only to bring himself up to date on the complexities of Hullian system making. For many years now, it has been nearly impossible for critics to grasp with any firmness the intricacies of Hull's theories, since the assumptions and the evidence basic to certain conclusions were often widely scattered and occasionally available only in a narrowly circulated mimeographed form. Now there should be little excuse for any psychologist to throw up his hands in despair, as so many have done in the past, when Hull's theories are mentioned, for the author has written a painstaking exposition of the development of his system and has, for the most part, succeeded in making it abundantly clear.

Whether the reader will be satisfied with the result will depend on his individual interests and critical standards. Hull has started out with a discussion of the nature of theorizing in psychology and has proceeded to show that his method is logically a sound one. Many readers who were skeptical about what Hull has been attempting will now be convinced that his aim is lofty and that his premises are unassailable. This part of the book is particularly valuable to the general reader.

As Hull proceeds to unfold the theory itself, a number of objections will occur to many readers. The author, for example, has tried valiantly to wash his hands of traditional stimulus-response connectionism. There has been too much experimental evidence tending to refute such notions for Hull to avoid paying lip-service to "molar phenomena." But it is only lip-service, and Hull must still be criticized for trying to get along with outmoded scientific constructs. The key to Hull's confusion is to be found on page 27, where he discusses the value of considering the problems of behavior dynamics that must be solved in the design of a truly self-maintaining robot. Despite its intellectual challenge, this is a scientifically stultifying exercise. Hull's purpose is to avoid "anthropomorphic subjectivism," and such avoidance is surely praiseworthy, but the attempt to explain rat behavior in terms of the psychologist's knowledge of machines is at least as fallacious as any explanation in terms of human behavior—and for the same logical reasons. In some ways, the danger is greater, for unless the theorist is exceedingly well versed in the most advanced branches of physics, chemistry, and biology, he tends to construct his robot in terms of primitive push-pull mechanisms. The seductive lure of such thinking has hounded psychological theory since Descartes, and Hull seems unable to avoid it even when he disclaims "molecular" explanations. Thus, on pages 68 and 69, Hull writes: "Just as the inherited equipment of reaction tendencies consists of receptor-effector connections, so the process of learning consists in the strengthening of certain of these connections as contrasted with others, or in the setting up of quite new connections." In one sentence, the author has begged the whole question of learning theory! Tolman, Köhler, and all the others who have inveighed against

connectionism for good and sufficient experimental reasons are thrown a sop in the early pages and then forgotten.

On page 95, Hull has written: "It follows from the conditions of compound selective learning assumed above that the organism by sheer trial-and-error will work blindly down through the series until . . . etc." Has all the evidence concerning the importance of perceptual factors in learning been lost on Hull? That evidence cannot be detailed here, but improvements in rate of learning which result from using elevated mazes, Lashley jumping stands, or 'obtrusive' cues in puzzle boxes have long since convinced many psychologists that the animal cannot be said to work "blindly." The reader can only conclude that, despite his protestations to the contrary, the author is an incorrigible connectionist whose predilection for robots leads him to ignore all the evidence which is really difficult to fit into his preconceptions of the nature of animal behavior.

Hull's publishers claim that this book presents the "first genuine theory of primary motivation." Many readers will feel that Hull has not even raised the questions that are fundamental to an understanding of motivation. The fact is that motivation, for Hull, is nothing but a pattern of stimuli, and evidence which contradicts such an assumption is ignored. The experiments of Wiesner and Sheard, to take but one example, are not even mentioned.

The criticisms presented here are culled almost at random from a list that is much too long for a short review. Hull has compiled a theory that is difficult to assess seriously because it exists in an experimental vacuum. The past thirty years have provided us with a mass of data which apparently conflicts with Hull's basic position. If it can be interpreted to fit S–R theory, we should be shown how. The reader of Hull's book might never know these data exist.

It is necessary to point out, however, that this is an important book: first, because it now offers in one place the body of an influential theory that has not previously been available as a unit; and second, because it is an exceedingly capable piece of exposition. Hull has written a stimulating argument, well-knit, clear, and stylistically pleasing. It is marred by a minimum of errors in proof-reading (though there is one serious one on page 154), and is in general a well-made book. The reviewer hopes that it will be carefully and critically read so that its influence on the graduate students of the next few years may be the more effectively combatted.

MAN AND HIS WORKS.

Edward Lee Thorndike. Harvard University Press, Cambridge. $2.50. 7¾ x 5¼; 212; 1943.

This little book comprises the William James Lectures that were delivered at Harvard University. The lectures, like Thorndike's research interests, are diverse, and yet they have been moulded into a meaningful series leading up to a general view of the relation of psychology to society.

The subject matter of the individual lectures will not be new to those who are familiar with the main currents of Thorndike's work. It is a matter of some regret, though certainly not of surprise, that Professor Thorndike describes the process of learning in the same terms of glowing simplicity that he has used for many years. His discussion of the development of language is equally familiar and equally subject to the criticisms which greeted it when it was newer. The lectures on measuring attitudes, on the 'goodness' of cities, etc., are similarly unaffected by theoretical controversy. Thorndike has been content to present to his new audience a mass of old material in a new and charming dress.

Few readers will fail to enjoy this discussion of how men acquire their social traits and how social relationships may be measured and bettered. If it is not new, it at least contains much that was new not so long ago and it is quite enough to demonstrate Thorndike's fertility and originality. As a sort of summary chapter to many years of valuable work, it is at once a milestone and a monument. It should be read with profit by psychologists and laymen alike.

THE INTERPRETATION OF DREAMS. *New Developments and Technique. In Two Volumes.*

By William Stekel. Authorized translation by Eden and Cedar Paul. Arranged for American publication by Emil A. Gutheil. Liveright Publishing Company, New York. $10.00. 8¾ x 5¾; Volume I, xi + 308; Volume II, v + 311–618; 1943.

This volume, the latest to appear of Dr. Stekel's monumental work on "Disorders of the Instincts and Emotions," is an able presentation of the author's theories, dealing with their practical application in dream interpretation. While accepting the Freudian dogma that dreams constitute the royal road to an understanding of neuroses, which Stekel calls parapathy, it discards the strictly Freudian passive method of free associations and has developed a method of active interpretation of dreams. Stekel asserts that it is unfair to allow patients to wander about in passive free association to dream material, that it is the business of the physician to offer an interpretation of life problems to which the passive associations certainly point. The patient "has come to us because he has a scotoma . . . our business is to discover the scotoma and to cure it." From this it is clear that Stekel's method diverges sharply from the strictly Freudian method in the injection of the physician into the situation. Stekel claims the discovery of the

symbolism of religion and the personification of parapathy. He gives numerous instances of both of these discoveries, and indicates how the patient clings to his parapathy and at every turn tries to defeat its cure by the analyst. Long continued analysis of dreams is often nothing more than the patient's successful evasion of efforts at cure on the part of the physician, and this process can be halted abruptly by calling the patient's attention to the fact or by refusing further analysis. The dreams of patients are very much influenced by the attitude and the particular interests of the analyst, and the very first dreams in an analysis are therefore the most important, since they are as yet uninfluenced by the analyst's personality and more clearly portray the structure of the neurosis.

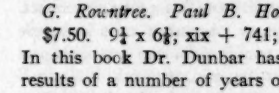
In the chapter on the religious symbolism of dreams Stekel shows that religious feelings are the source of important conflicts in the lives of patients and that not all dreams are reducible to terms of Freudian psychosexuality.

There are chapters on the representation of parapathic symptoms, individual dream symbols, and symbols of the mind. A chapter on the progress of dream interpretation is especially important because it contrasts the "material interpretation," in which the dream material is reduced to Freudian sexual terms, with "the functional interpretation," in which the dream material is reduced to a symbolic representation of the neurosis and its interference with normal functioning. The analysis of dream series completes Volume I.

Volume II is devoted to the patient's relation to analysis as expressed in his dreams, to dreams and intuition, to the analysis of a case of dyspareunia, to the dreams of a homosexual man, and includes a final chapter on the technique of dream interpretation. Stekel lays great emphasis on the manifest dream content, insisting that from this material alone it is possible to get an adequate functional interpretation of parapathy. Critics have claimed that his method is intuitive and not teachable. The purpose of the book is to show that the method is teachable, and to a considerable extent this reviewer would say that he has fulfilled his objective. It may be only a dearth of experience and a lack of the proper kind of imagination on the reviewer's part that make it impossible for him to follow easily several instances of dream interpretation.

This text, like other volumes on dream analysis, serves to emphasize the important contribution of psychoanalysis to the incorporation of dreams into the continuum of mental functioning. I have no doubt that the author has had notable success in handling dream material by his method. There is no doubt either of the success attendant on Freudian methods—all of which goes to show that the influence of the analyst on the patient is the essential curative element. Whether this is to be accomplished by active or passive means must surely depend upon the patient and the analyst.

The translation is excellently done, and the volumes are pleasantly readable. They should be in the hands of all serious practising psychiatrists.



PSYCHOSOMATIC DIAGNOSIS.
By Flanders Dunbar. With a Foreword by Leonard G. Rowntree. Paul B. Hoeber, Inc., New York. $7.50. 9¼ x 6⅛; xix + 741; 1943.

In this book Dr. Dunbar has brought together the results of a number of years of research and practice in the field of psychosomatic medicine, a term which she herself coined, if I am not mistaken. The book is divided into parts dealing with psychosomatic history-taking, special techniques and examinations, special psychosomatic syndromes, personality profiles in the different syndromes, general theory and criteria for treatment, and some considerations for further research and basic principles. The special syndromes include fractures, hypertensive cardiovascular disease, coronary occlusion, anginal syndrome, rheumatic fever, rheumatoid arthritis, cardiac arrhythmias, recurrent decompensation, and diabetes. Clearly a large number of psychosomatic difficulties have not even been touched on in this volume, including the whole group of gastro-intestinal disorders, skin diseases, headache, etc.

In the chapter on psychosomatic history-taking, Dr. Dunbar quite rightly stresses the spontaneous production of patients. She decries the questionnaire method. One may gather that her critique of questionnaire is directed to psychiatric procedures which are not based on psychoanalytic understanding. If this is so, there is a grave misunderstanding on her part, because even so-called questionnaire methods are never as rudely applied in the hands of experienced psychiatrists as the reader might be led to believe. Any experienced psychiatrist will follow his nose in the investigation of the material and will depend largely upon the spontaneous production of the patient. Even Dr. Dunbar in her examination manages adroitly to lead the patient on, as any other psychiatrist would. This is said in no carping sense whatever, but throughout the book there is the insistence that unless a physician is psychoanalytically trained he cannot possibly understand fully the material under his view.

It is impossible to give all the conclusions arising from the investigation of each one of the specific syndromes, and it would be unfair to reduce the material to a matter of contrasting profiles, so that what follows must be taken, as I am sure Dr. Dunbar would wish, only in the sense of useful hints from the material. She states, "Coronary occlusion and hypertensive cardiovascular disease seem to occur particularly frequently among top-dogs and would-be-

top-dogs. Anginal syndrome is a frequent finding among prima donnas or big frogs in small puddles. Rheumatic fever and rheumatic heart disease occur among teachers' pets and martyrs. Patients with cardiac arrhythmia, although they have something of the prima donna, give the impression of being children in the dark. Patients with diabetes can generally be characterized as muddlers."

Anyone who has worked with psychosomatic problems for any length of time must be forced to the conclusion that the validity of theories in this field rests to an enormous extent on the historical chronology of events, on the juxtaposition of special items which through the physician's attention or the patient's attention come to assume cause and effect relationship. The literature on the subject is amazingly meager in more accurate definition of the actual relationship of psychic to physiological events. Dr. Dunbar's use of statistical method bolsters the assumptions derived from historical material, but even such a thorough investigator as Dr. Dunbar can be too enthusiastic over her own findings, one may surmise. When a patient who has had several fractures is reported, after an episode of personal chagrin, to have gone out and acquired himself another fracture, one can only recognize that the author has accepted her own conclusions entirely too readily. It remains to be proven, for example, that the guilt reactions of fracture patients have any more importance than a casual consequence of the fracture. For example, "A married Irish-born housewife . . . fell off a step-ladder, fracturing the os calcis of the right foot. She said she had been having a queer feeling that she had done something wrong. She wasn't sure what. 'I always tell my children if they get hurt it's a punishment because they have done something wrong and they'd better confess.'" This statement of the patient would seem to me to throw more light on her cultural background than any actual illumination on the causes of her accident. Maybe Dr. Dunbar doesn't think so, but there are various ways of looking at this material.

The book is an impressive piece of work, and the author and her colleagues have done a remarkable job in ferreting out personality profiles and actual precipitating situations in each one of the psychosomatic syndromes. The summaries that they have arrived at may be taken as representing a distillation of general expectations in such cases, pointing the way to things that need to be inquired into and determining special attitudes in treatment, and special treatment procedures. The material on the Rorschach test is valuable and needs further expansion, such as it is receiving at this moment.

In spite of the excellence of the work, this reviewer feels that it would be better yet and exercise a more profound influence among physicians generally if the material were presented in a less dogmatic way from the psychoanalytic viewpoint. There must be plenty of physicians who are willing to accept a formulation of psychosomatic material couched in terms of universal acceptance. This kind of a book is yet to be written. When it is, Dr. Dunbar's experience will be one of its basic pillars, but it will be a different edifice than her's.

INTRODUCTION TO EXCEPTIONAL CHILDREN.

By Harry J. Baker. The Macmillan Company, New York. $3.50. 8¾ x 5¾; xiv + 496; 1944.

Here is a text for teachers, having to do with the problems of exceptional children of all types: those physically handicapped, those victims of neurological or mental diseases, those with behavior difficulties, those with educational retardation, and those exceptional for other reasons or for a combination of reasons. It is an eminently practical text, dealing with experiences in actual practice in the Detroit school system and other situations, and gives a broad view of the problems to be met and methods for their management. The author makes a telling point in stressing that the exceptional child commonly puts forth a very unusual effort to gain what training he acquires; further, that if normal children in normal situations put forth the same efforts that the exceptional children have to, no one knows what the effect of this would be on the general cultural development. He makes a plea for humane enlightened treatment of the exceptional child from the physically handicapped and subnormal to the gifted child. The author, however, is too much swayed in his chapter on psychotic conditions by the seeming erudition exhibited in the American Psychiatric Association's official classification of mental diseases. As a matter of fact very few mental diseases are attributable to neurological disorders, but this is a minor item and of no great importance for the purposes of this book. It seems to be an excellent text on the subject.

THE RIGHTS OF INFANTS: *Early Psychological Needs and Their Satisfaction.*

By Margaret A. Ribble. Columbia University Press, New York. $1.75. 8¼ x 5¼; x + 118; 1943.

It has long been known that many of the social and psychological maladjustments of later life have their origin during infancy, and can be traced to certain social and psychological patterns of behavior in early life. The present study is concerned with the behavior of the very young infant: his tensions, his satisfactions, his instinctive reactions to his earliest surroundings, as related to his development as a normal integrated individual. A close and loving mother-child relationship is stressed throughout, and many instances are cited to show that lack of affection for the child, on the

part of the mother, with the consequent lack of fondling, caressing, and stimulating, in a hundred ways results in a thwarted and psychologically maladjusted individual, incapable of reacting normally to his surroundings, even in later life.

From her interestingly recorded observations of infant behavior, Dr. Ribble has drawn the following conclusions: (1) that crying is not simply the infant's method of letting his elders know he is unhappy, but rather its method of increasing the oxygen supply required to maintain its feeling of well-being; (2) that sucking is not merely for the purpose of supplying the young infant with food (since, during the first week of life, the quantity of food involved is very insignificant anyway), but rather its method of stimulating one of the most sensitive regions of the body, while at the same time discovering something of the environment; and (3) that the infant's bath is not nearly so necessary as a measure of cleanliness as it is for stimulating the baby's body, and thus satisfying the innate desire for being fondled, caressed, and handled.

The author makes a final plea for the careful development of the emotions during early infancy, so that by the time the individual is old enough to control them intellectually, they will not be thwarted or dormant, or completely lacking.

For those interested in child behavior and development, as well as for those concerned with general human psychology, this volume will prove both stimulating and enlightening. An index and a bibliography are provided.

ENCYCLOPEDIA OF CHILD GUIDANCE.

Edited by Ralph B. Winn. The Philosophical Library. $7.50. 9 x 6; 456; 1943.

A total of 74 authors have contributed to this excellent 456-page compendium of the latest scientific knowledge concerning child guidance. Some 215 topics including such items as anger, competition, fear, lying, phobias, punishment, imitation, and hobbies are discussed authoritatively, and in the light of the research and experiences of the contributors of the various topics. The contributions touch every conceivable phase of child guidance from medicine, pediatrics, psychology and psychiatry, through hygiene, health and dietetics to education, sociology, and even anthropology.

The editorial work, which included the selection of entries as well as the organization of the entire body of material, has been skilfully handled. The result is a reference work which will prove extremely useful, not only in the university, child clinic, or child welfare library, but in the home as well.

MODERN WAYS WITH CHILDREN.

By Elizabeth B. Hurlock. Whittlesey House, New York and London. $2.75. 8 x 5½; vii + 393; 1943.

The impact of war, probably more than any other single factor, has renewed the emphasis on the need for more and better child care and guidance. With so many fathers away at war, and so many mothers taking important places in industry, the care of countless children is left to inexperienced nursemaids, boarding schools, or haphazard arrangements of pooling or sharing caretakers. It is felt that under such conditions, too many children will, like Topsy, just grow up, with no concept of their obligations to society, or of society's obligation to them.

In the present volume, the author has attempted to bring to the lay public the latest scientific knowledge on child training in clear, precise, and non-technical language. Such problems as eating, sleeping, playing, habit formation, and discipline are discussed from an entirely sympathetic, yet intelligent point of view. The author's closing sentences depict the straightforward common sense displayed throughout the volume: "By guiding the child's behavior, by encouraging him to develop wholesome attitudes, by correcting any distorted points of view that he may have, and by checking any behavior which gives promise of being undesirable, you will help to lay the foundations of a well adjusted personality. That is all you can hope to do in the childhood years."

For mothers, fathers, and nursemaids—in fact, for anyone vitally concerned with the care and guidance of children, this work should prove to be a fundamental source of help and encouragement. A list of suggested readings and an index are appended.

MENTAL HYGIENE IN SCHOOL PRACTICE.

By Norman Fenton. Stanford University Press, Stanford University; Oxford University Press, London. $4.00. 9 x 6; xvi + 455; 1943.

Professor Fenton has here compiled a most challenging book on mental hygiene in the school. The book is divided into five parts: How mental hygiene serves the school; Fundamental points of view in the practice of mental hygiene; Individual guidance, the theory and practice of school case work; Mental hygiene and the teacher; Mental hygiene and community life. In addition there is an appendix which includes a very good selection of books on child guidance for parents and an extensive bibliography.

The author has taken a very sensible attitude toward the whole problem of mental hygiene in the school and sees it as a program to be fostered by the joint efforts of teachers, parents, physicians, and other interested parties, and to be promoted perhaps by the training of specialists in mental hygiene taken from the ranks of school teachers themselves. He gives constructive examples of how such a program has been achieved in various situations, the obstacles that had to be overcome, and the practical methods employed in their resolution. Nowhere in the text is there any

evidence of any special bias concerning methods to be employed. The book remains on a very practical ground and must rank as a first rate presentation of mental hygiene work, as it is actually practiced in schools today and as it could be promoted in different settings throughout the country.

Part three, entitled "Individual guidance, the theory and practice of school case work," includes chapters on "The origins of symptoms and problems," and on "Symptom-formation as adjustment." In these two chapters the author gives a very good presentation of the issue of symptoms and their formation and meaning, without in any wise allying himself with those special interpretations which, whatever their provocation in a strictly medical setting, would no doubt be met with too much skepticism by the non-medically trained and by those who with medical training would still object to scientific bias.

In part four, "Mental hygiene and the teacher," the author presents some instructive case records of successful and unsuccessful teachers, showing what practical measures were applied in the treatment of personal difficulties in the lives of teachers. These are very abbreviated accounts, and the reader might get an erroneous impression of the ease with which favorable results were obtained.

Altogether the book is a most welcome text on the subject and should stimulate the spread of mental hygiene programs throughout the country.

HUMAN BIOLOGY

SOCIETY AND NATURE. *A Sociological Inquiry.* *By Hans Kelsen. University of Chicago Press, Chicago.* $4.00. 9 x 6; viii + 391; 1943.

The author's purpose in writing this book seems to be to show the debt that our modern philosophic and scientific theorists owe to the thoughts of their primitive ancestors. The first part of the book reads like an excerpt from Fraser's *Golden Bough.* The final chapters are devoted to expounding the parallelism between primitive folk lore and advanced philosophic thought. The author's thesis is well summarized in his closing sentence as follows:

"After the complete emancipation of causality from retribution in the modern notion of law, society is—from the point of science—a part of nature." The rest of the book is like a discourse developed from this text.

There are 118 pages of bibliographic references and other notes, and 7 pages of index.

SOCIAL THERAPY. *An Introductory Study.* *By M. B. Hale and S. M. Hale. Williams and Norgate, Ltd., London.* 5s. 7¼ x 4¼; 96; 1943.

This is a handbook for the use of social service case-workers, compiled from the experiences of the London Charity Organisation Society. It is an excellent little book dealing with equipment, interviewing, the background of the whole problem of social therapy, visiting, treatment, conference and committee work, and recording. The book is eminently of a practical nature and avoids all kinds of isms which have tended to dominate the field in various settings. The authors acknowledge the indebtedness of the movement in England to American methods of social care, and the adaptation to English soil seems to have resulted in a thoroughly practical and useful work. It is a volume which tells its story simply, and might easily be a useful handbook for American, as well as English, case-workers.

CRIMINAL CAREERS IN RETROSPECT. *By Sheldon and Eleanor Glueck. The Commonwealth Fund, New York.* $3.50. 9¼ x 6; xiv + 380; 1943.

This is the report of the third five-year follow-up of five hundred criminal careers, and is actually a summary of the progress upward or downward in the careers of the five hundred original criminals, treated statistically and treated at length in illustrative sample. Briefly, some of the five hundred improved their status; for some of them matters stood definitely worse.

In summarizing the differences between success and failure, the authors point to the age of the first delinquency as the one most significant factor. "A greater proportion of those who responded well to each form of peno-correctional treatment were further along in years when they first became delinquent than of those who did not respond satisfactorily to treatment; among the latter delinquent trends became evident very early in childhood. It is to be stressed that this is the only factor in respect to which all the treatment failures were consistently and uniformly inferior to the successes. This finding would seem to suggest that inability to adapt to peno-correctional treatment is somehow related to biological difference between successes and failures."

The authors then proceed to the most provocative part of the work, namely, the construction of a table from which a prediction concerning the behavior of delinquents may be made with substantial chances of the prediction turning out accurately. Without going into the detailed construction of the prediction table, it may be stated that the authors feel that if such a table is applied in the proper spirit, namely, not as a slide rule to indicate automatically the proper type of peno-correctional treatment, but as an index to guide the sentencing authority in his choice of sentence, a great deal more might be expected of peno-correctional treatment than is the case today. "... it becomes clear that the sentencing process must be transformed

into systematic and informed fitting of the offenders to treatment. . . . the prediction tables as well as illustrative analyses of their choice have demonstrated that Justice need not be blind in an undesirable sense." Actually, this means that authorities who sentence must have considerable latitude in imposing the sentence and that its nature should be determined after joint consultation between legal authorities, psychiatrists, psychologists, and criminologists. The authors state, "We are thus led to the conclusion that it isn't primarily or fundamentally the fear of punishment, but rather the presence or absence of certain traits and characteristics in the constitution or the early environment of the different offenders which determine their respective responses to the different forms of treatment, and determines also what such offenders will become and what will become of them. Those who behaved well, either during or after treatment, were as a class more favorably endowed by nature and circumstances, by nurture, than were those who did not respond well." The prediction tables are the translation into mathematical formulae of the material whose analysis led to the above conclusion. The authors are in the process of applying the prediction tables to some of the cases with the hope of checking up on the actual outcome at a later date.

RACE AND RUMORS OF RACE. *Challenge to American Crisis.*

By Howard W. Odum. University of North Carolina Press, Chapel Hill. $2.00. 7¾ x 5⅛; + 245; 1943.

The problem of race discrimination (which some will always refuse to recognize as a problem) and biracial culture in the United States must have an early settlement if the principles for which the present war is being fought overseas are to be realized here at home. The threat of open riots between whites and Negroes in various parts of the country during the first year of the present war has served to emphasize the seriousness of the problem, and has prompted the present attempt to collect and scrutinize some of the underlying factors and relationships.

The unusual circumstances brought on by the war (for example, the crowded transportation facilities and the resultant difficulties in enforcing the Jim Crow laws) have placed the South on the defensive with respect to its treatment of Negroes. The South has fought for a hands-off policy, and has insisted on its ability to cope with a problem which it feels is no concern of any other part of the country.

The author believes that the South can no longer consider itself isolated from the rest of the United States, any more than the nation can consider itself isolated from the rest of the world. In other words, the problem is no longer localized, nor is it any longer a problem of primary concern only to the United States, but it is a world problem which will certainly have its solution in the culmination of the present world conflict, if not before.

Meanwhile, for those of us who face the problem at close range the author makes a plea for an intelligent and realistic analysis of the situation as it exists. He clearly indicates the need for careful sifting of the pertinent elements of the problem to determine which is truth and which is rumor; which is real and which is only apparent; which is related and which is not related to the basic difficulty.

In the words of the author, the work is ". . . literally an affectionate appeal to all the people of the Nation and a challenge to its leadership for wisdom and maturity, bottomed in the facing of truth wherever found; in the asking of essential questions; in the search for correct answers. The eager quest for a new covenant through scientific and cooperative endeavor on new high levels leaves no place for bitterness and hate, for name-calling and blame, for flight from that reality which is America's heritage and opportunity."

CHARACTERISTICS OF THE AMERICAN NEGRO.

Edited by Otto Klineberg. Harper and Brothers, New York. $4.00. 9⅛ x 6⅛; xii + 409; 1944.

In this volume are collected several of the monographs which were submitted to Dr. Gunnar Myrdal in his study of the Negro in America, recently published under the title, *An American Dilemma.* The contents include: "The Stereotype of the American Negro," by Guy B. Johnson; "Tests of Negro Intelligence" and "Experimental Studies of Negro Personality," by Otto Klineberg; "'Race' Attitudes," by Eugene L. Horowitz; "The Hybrid and the Problem of Miscegenation," by Louis Wirth and Herbert Goldhamer; and "Mental Disease Among American Negroes: A Statistical Analysis," by Benjamin Malzberg. Johnson collected popular beliefs and assumptions among American whites concerning the American Negro, and when one reads this compilation, one can only blush at the high rate of assumption and the low rate of proven fact at its base. A final summarizing list of Negro personality and cultural traits is presented as a basis for further discussion and research. Klineberg's study of Negro intelligence is based largely on material from the Army tests of 1918, which shows the northern Negroes making a much better performance on the tests than southern Negroes, and northern Negroes doing somewhat better than southern whites, differences which Klineberg relates to the cultural setting and opportunities for self-development. The problem of Negro personality runs into the same difficulty that all personality studies do, with the added factor that the Negro has not as yet been the object of extensive study. Horowitz' contribution on "race" attitudes

is very interesting and shows clearly that there is no spontaneous race attitude in young children; that this begins to develop in about the 5th grade in school, clearly as a consequence of cultural social pressure. Wirth and Goldhamer discuss the hybrid and the problem of miscegenation, reaching the important conclusions that the possibility that the Negro will be absorbed into the white population through thorough miscegenation has little to support it in actual trends today, that the mulatto is apt to disappear as such from the American scene, and that the Negro "race" will become fairly stabilized. Malzberg shows that Negroes have the same mental diseases as whites, and their tendency to have certain mental diseases in greater proportion than whites is most likely closely related to social and cultural factors.

This is an important book, and its reader cannot help but be appalled at its revelation of the pathetic poverty of actual fact as opposed to the plethora of assumption, for the most part prejudicial to the Negro, which make up the conception of the American Negro most whites in this country definitely possess. Every page points to the need for further systematic, carefully controlled observation of one of our most important social, economic, political, and biological problems.

AN AMERICAN DILEMMA: *The Negro Problem and Modern Democracy. In Two Volumes.*

By Gunnar Myrdal, with the Assistance of Richard Sterner and Arnold Rose. Harper and Brothers, New York. $7.50. 9⅛ x 6⅛; Vol. I, lv + 705; Vol. II, xii + 709–1483; 1944.

This excellent work gives not only a well-rounded presentation of the American Negro and his impact upon American society, but it is at the same time a penetrating sociological study of the United States.

Gunnar Myrdal, Swedish social economist, was chosen to make the study because the Carnegie Corporation, which financed the work, felt that only a scholar from a country with no traditions of imperialism could approach the problem with the requisite impartiality. In the collection of factual material and its interpretation Dr. Myrdal was aided by a large staff of assistants, headed by Richard Sterner and Arnold Rose; but the evaluations and conclusions are the product of the author's scientific analysis, and not a compromise between various racial and regional viewpoints. The result is a cohesive and thoroughly readable book. At the same time, divergent views on most phases of the question are quoted and analysed.

The book is encyclopedic in scope. It embraces attitudes, beliefs, Negro ancestry, population, and migration; economics, politics, justice, education, religion; treats of every form and variation of discrimination and the reactions thereto; describes the Negro community and individual achievements and contributions. Although the names and often the faces of celebrated Negro artists and athletes are generally known, the white American is, as a rule, totally unacquainted with the educated Negro. Myrdal testifies to the warm, deep, and rich personalities of educated Negroes. "Whether they know it or not, white people are dwarfing their minds to a certain extent by avoiding contacts with colored people."

Organizations of and for Negroes are painstakingly analysed. Myrdal points out that "some of the most capable statesmen in the United States are Negroes," but their tact and ability, sorely needed by the country as a whole, are completely absorbed by the struggle to get the white man to live up to the letter and spirit of the law.

As a social scientist, Myrdal of course makes no attempt to add to our biological knowledge of race. In the biological field he is concerned chiefly with the effect of false beliefs about race as a rationalization for discrimination.

Every phase of the life of the American Negro is comprehensively treated. The historical past is reviewed, and here the author takes issue with the popular practice in scholarly histories as well as in school texts of ignoring the accomplishments of the Reconstruction Period that followed the Civil War. Myrdal finds that the Southerner cherishes the memories of the "horrors" of the Reconstruction governments as a vital defensive in order to condone the "legal trickery, unfair administration, intimidation and forthright violence" he uses to disfranchise Negroes in the South today. The Northerner, "in order to rationalize the national compromise of the 1870's and the condoning, since then, of the South's open break with the spirit of the Constitution," supports the Southerner's interpretation.

The Negro's economic, political, religious, and social life are given exhaustive treatment. Of equal, if not greater, interest is the analysis of what effect our attitude towards the Negro has on American economy and politics as a whole and on our moral character.

Several years of research and field investigations (the inquiry was started in September 1938 and ended in September 1942) brought Dr. Myrdal to the conclusion that there is no Negro problem except in the heart of the white American. Once the white American accepts the Negro as the equal human being that science proves him to be, the Negro problem as such will disappear and all Americans could then start working together for better housing, cleaner politics, and for every common problem that faces the nation. In the meantime "*personal and local interests; economic, social, and sexual jealousies; considerations of community prestige and conformity; group prejudice against particular persons or types of people; and all sorts of miscellaneous wants, impulses, and habits*" are responsible for our living, thinking, and acting in direct

violation of the American Creed of liberty, equality, justice, and fair opportunity for everybody. It is his strong and genuine belief in the American Creed that has forced the Southerner to build up an amazing edifice of rationalization for his inhuman treatment of the Negro. He has convinced himself that he is the guardian of the "purity of the white race." The white Southerner claims to refuse social equality because it would lead to "intermarriage." Myrdal, however, believes that actually it is the other way around: "intermarriage" is resented because it would be a supreme indication of "social equality," and *"what white people really want is to keep the Negro in a lower status."* Thus "the great majority of non-liberal white Southerners utilize the dread of 'intermarriage' and the theory of 'no social equality' to justify discriminations which have quite other and wider goals than the purity of the white race." The author blasts the myth of Negro contentment, even when applied to the most apathetic of the poverty-stricken masses: "If a multitude of first-hand random observations, such as we have made over the whole country, are any evidence, the contented Negro . . . is a rare phenomenon."

Myrdal points out that the findings of anthropological research are making it increasingly hard for the white Southerner to live with his conscience. The conflict between the American Creed and his prejudices "makes the prejudiced white man nearly as pathetic as his Negro victim." It is interesting that Myrdal's conclusion that the white Southerner is suffering from a "deeply split personality" is identical with that of Lillian Smith, editor of the Georgia periodical, *South Today*. Miss Smith, a native-born Georgian, is a child psychiatrist whose work with the children of prominent Southern families has led her to the conclusion that the Southern mind and soul have been warped by a teaching which tacitly implies that no matter what wrongs a white child commits he is superior to the best Negro child. Myrdal, too, points to many disastrous consequences of our illegal treatment of the Negro. For example, contempt of the law in this sphere breeds general contempt of law; miscarriage of justice towards one group breaks down our entire judicial machinery.

The international aspects of our prejudice are of course well known to serious students of world affairs. Myrdal reiterates their plea that we come to good terms with colored peoples before the white minority in the world's population is in its turn humiliated and subjugated.

As to the physical makeup of the book, it is deplorable that the footnotes of both volumes (which are as interesting and as readable as the text itself) have been included in Volume II, thus making it necessary for the reader to have both volumes beside him if he wants to read Volume I intelligently, and also cutting in half the possibilities for circulation among library borrowers.

THE AMERICAN WOMAN. *The Feminine Side of a Masculine Civilization. Revised and Enlarged Edition.*

By Ernest R. Groves. Emerson Books, Inc., New York. $3.50. 8⅜ x 5½; 465; 1944.

Some years ago the reviewer was given a book called "What Every Man Knows About a Woman." Inspection of the book disclosed that every page was completely blank.

How does it happen that a mere man can presume to produce a work on this subject of the magnitude of the volume under consideration? A glance at the table of contents reveals the answer. This is not so much a book about women as about what men have thought of, and have done to, women in the past twenty centuries. The opening chapter begins with the admonitions to women concerning their demeanor in public places of worship from the letters of Paul to the Corinthians, and recounts the results of the mutual impacts between women and civilization ever since. The author enlarges upon the cultural influence of all women, from those who enter convents to those who follow another profession, more ancient but less honorable.

The reader who glances over the 27 pages of index will doubtless be surprised at the proportionate space accorded to some of the significant women of history. For instance, Frances Wright, Louisa May Alcott, Mary Baker Eddy, and Marie Curie are mentioned but once; Lucretia Mott and Amelia Bloomer but twice, and Nancy Hanks and Sarah Josepha Hale not at all. The most prominent figures appear to be Elizabeth Cady Stanton, Susan B. Anthony, Mary Wollstonecraft, and Dorothy Dix. At first sight this seems to be a strange selection, but a careful reading of the text seems to confirm the author's choice.

To the reviewer the most interesting chapter is that in which the cooperative venture of Robert Owen at New Harmony is discussed. This neglected phase of American social history deserves more attention than it commonly receives, for it made many significant contributions to other phases of the intellectual development of the republic as well. But other readers may feel differently, since every phase of United States history is covered equally well, and the story is brought down to date by a discussion of the problems of employment that confront Rosie the Riveter. The author even goes so far as to maintain that the difference in the social position accorded to women of the two groups of nations participating in the present war is the most fundamental difference in the two competing social philosophies.

ITALIAN OR AMERICAN? *The Second Generation in Conflict.*

By Irvin L. Child. Yale University Press, New Haven. $2.75. 9¼ x 6; vii + 202; 1943.

The psychological and social adjustments of a genera-

tion whose parents have migrated to a new country are complex, particularly when the cultures in the old and new country differ in language, family patterns, and community life. This study deals with the process of acculturation in such a group, the male second-generation Italians in New Haven, Connecticut, being chosen for study. First- and second-generation Italians constitute about one-quarter of the city's 160,000 population, approximately equalling the fraction of the city which is native white of native parentage.

A community of this constitution presents an excellent opportunity for such a study, but the material on which this study was based is exceedingly meagre. It consists of standard interviews with fifty-three persons, informal interviews with twelve persons, life histories obtained from three informants, and general observations made after boarding for several months with Italian families and participating in their daily social life.

Three types of reaction to the problems of acculturation are described in detail: the rebel reaction (based on ten cases), the in-group reaction (nine cases), and the apathetic reaction (twelve cases). The remaining group of informants (nearly half of the total) showed reactions which were not predominantly in any of these classes and are not discussed to any extent in the book. The people in the first class attempt to affiliate themselves with the Americans in the community, those in the second maintain their identity as members of the Italian group, and those in the third cultivate an indifference to national distinctions. The conflicts and achievements associated with these various reactions are discussed.

The book presents interesting ideas upon which to speculate regarding important social problems, but in view of the limited amount of evidence supporting any of the ideas, it can hardly do more than suggest issues toward which a real community study might be directed.

THE DISPLACEMENT OF POPULATION IN EUROPE. *By Eugene M. Kulischer. International Labor Office, Montreal and London.* $1.50. 9¼ x 6½; iv + 171; 1943.

One of the most serious post-war problems will be the resettlement of the millions of people who have been transplanted from their homes and homelands. Any sensible reconstruction requires knowledge of the extent and nature of these population movements. The International Labour Office has undertaken to assemble such knowledge as is at present available. Such a project presents enormous difficulties, first in amassing figures which will give even a reasonable approximation to the true values, and second in organizing them in such a way that important patterns in the situation emerge.

In collecting the figures, Dr. Kulischer has received the assistance of a large number of official and private organizations. In cases where wide discrepancies in estimates from different sources appear, he presents the discordant figures and brings collateral evidence to bear in an attempt to get as good approximations as possible. He makes allowances for the duplication of persons, which must inevitably occur in recording movements of people under such chaotic conditions. In all, he estimates that some thirty million people in Europe are living away from their pre-war homelands—exclusive of the men in the armed forces who are abroad and the axis soldiers who have been taken prisoner. Other large groups that are omitted, such as the evacuees from German and Italian cities subjected to recent bombings, make the estimate given above conservative.

The movements of the populations are described under three heads: migration movements of the German people; movements of non-German populations; mobilization of foreign labor by Germany. The first class includes the transfer of German minorities to Germany or the new border provinces under a repatriation scheme (750,000) and the migration of Germans out of the Reich to conquered or occupied countries (2 to 3 million). The second class includes an enormously varied set of migrations, which are analyzed country by country. It involves some 14 to 15 million non-Jews and 3 to 4 million Jews. The third class, again analyzed country by country, concerns between 6 and 7 million persons brought into Germany for the labor market between the end of 1939 and the beginning of 1943.

The text that presents the figures is very well written, presenting the forces behind the various movements, both according to the official statements, and according to the probable facts. This is done without emotionalism, but with an understanding of the implications for the peoples involved. It is a book which should interest any person concerned with the world picture, and even though the report is of necessity provisional, it should be a very valuable aid to those who are in any way responsible for post-war settlements.

BURIAT MONGOLIA. *A Brief Survey of Political, Economic and Social Progress. By V. I. Pomus. Abridged and Translated from the Russian Work "Buriat Mongolskaia A.S.S.R." by Rose Maurer and Olga Lang. With an Introduction on Recent Developments by Rose Maurer. Institute of Pacific Relations, New York.* $1.00 (paper). 11 x 8½; 76; 1943.

This survey is an abridged translation of a Russian book that appeared in 1937. Miss Maurer in her excellent introduction describes the development of Buriat Mongolia from that date until 1942. The book gives a valuable insight into the great changes

that have been brought about by the Soviets in Central Asia and into the Soviet policy toward minority nationalities.

After a brief sketch of the geography, natural resources, and history of the area the author discusses at length the economic and cultural development since the Russian revolution.

The Buriat Mongols of Lake Baikal have been organized into the Buriat Mongolian Autonomous Soviet Socialist Republic (BMASSR) with Ulan Ude, formerly Verkhneudinsk, as capital. The nomadic and semi-nomadic Mongols were settled on collective farms, and the vast steppe and *taiga* lands are now dotted with new villages. The economy of BMASSR was incorporated into the national economy of the USSR. At Ulan Ude the Soviets constructed the largest locomotive and railroad car factory of the USSR. It repairs rolling stock as well as turning out new equipment for the Far Eastern and Siberian railroads. This and other newly constructed plants use local raw materials such as coal and natural gas. At Ulan Ude the largest meat *combinat* of the USSR, a part of which is the first meat canning factory of Siberia, is also located. The Buriat Mongolian alphabet was latinized in 1930 and has since been used in schools, business, and public life. Literacy rose very rapidly, especially among the Buriats, as a result of the expansion of the school system in the fall of 1936 to include all children of school age.

SOCIAL CHANGE IN SOUTHWEST CHINA. *Case Study 1: Three Types of Rural Economy in Yunnan*, by Yu-I Li, Hsiao-Tung Fei, and Tse-I Chang. Edited by Hsiao-Tung Fei. *Case Study 2: Labor and Labor Relations in the New Industries of Southwest China*, by Kuo-Heng Shih and Ju-K'ang T'ien. Edited by Francis L. K. Hsu. *Case Study 3: Magic and Science in Western Yunnan: The Problem of Introducing Scientific Medicine in a Rustic Community*, by Francis L. K. Hsu.

Institute of Pacific Relations, New York. No. 1, 35 cents (paper); No. 2 and 3, 50 cents (paper). 11 x 8½; No. 1, 35; No. 2, 45; No. 3, v + 53; 1943. These three mimeographed studies of the changing social conditions in Yunnan prove to be deeply interesting. Made by sociologists of the National Yunnan University who have been forced to the interior from their coastal universities by the war, they are a product of that opening up of southwest China to industrialization and modern influences brought about by the conflict with Japan. Of this southwestern area, Cressey has said, "The southwestern tableland is the most diverse region in all China in its human make-up. Only about half of the population consists of real Chinese and the remainder is made up of a great variety of primitive peoples. . . . Perhaps few parts of the world contain such a complicated racial mixture or offer such a fertile field for the study of anthropology as this region and the adjoining mountains" (*China's Geographic Foundations*).

The opening up of this region will inevitably alter and obliterate much of the existing pattern of social organization. At the same time, the seeds of China's uture as a great political and industrial power are here, along with many difficulties and problems that lie in the way. The enthusiastic young sociologists who have made these studies have eschewed the bird's-eye view, believing that it is better to look "at the subject from the lower strata, and within a limited field, giving an intensive and rather detailed picture of the unit covered, a microscopic view, without however losing sight of the wider implications." To the reviewer, who grew up in China, the result is illuminating beyond almost anything, within his knowledge, that has been written about that land.

The first study compares the rural economies of three communities. The first of these is a mixed community of Chinese and Lolos, lying in the hill country, and scarcely removed from a feudal state. The second is a wholly Chinese community of petty landowners on the fertile riceland of the plateau. The third is a riverside community in an area of poor agricultural resources, where primitive industry, in the shape of basket-weaving and papermaking, is necessary to support the population.

The second report deals with labor conditions in two of the new wartime factories in Kunming, one factory employing wholly male labor and the other female. The investigation includes a survey of the character of the labor supply, the origins of the laborers, and the factors leading to their employ; the existence of a social dichotomy in the factory personnel, and the problem of efficiency; the role of management and its special difficulties in attempting to apply the impersonal labor system of mass production to people for whom personal relations are all-important and traditions of hand labor and craftsmanship are strong. Students of the Industrial Revolution who would like to see, at first-hand, situations paralleling those in England and Europe in the eighteenth and nineteenth centuries will find them in western China today.

The third report will be of most interest to biologists in general, for it deals with the reactions of a town of about 8000 population to an epidemic of cholera. The town possessed several missionary churches and a college, a modern 20-bed hospital with two doctors and a nurse, a public library, and three schools enrolling 1400 students. Contrary to the generally accepted theory that "magic fills the gaps of science" (Malinowski), it is clear that in this town there is no replacement of traditional practice by that dictated by scientific knowledge. On the contrary, scientific knowledge is merely fitted into the traditional pattern of magical doings and superstitions without any

rupture in the fabric of the latter, and without any true understanding. The scientific remedy comes to be regarded as but one of a number of possibly effective traditional methods to be tried. The author concludes that "In a society of slavery, or of caste, or of fate, even with all the industrial development of the world, sound scientific reasoning can never really hope to take a permanent root. Only in a free and industrialized society will education on a large scale (i.e. mass education) be possible and become of real social value, for then education will receive the support of the mass of the people."

There are certain faults in the studies, faults probably unavoidable in view of the methods used and the circumstances surrounding the investigations. The data are rather frequently too scanty for statistical treatment, and conclusions that are unreliable are sometimes drawn. Notwithstanding these defects, it is vastly encouraging for the future to see scientific case studies of such merit appearing from China during its present ordeal, and the translation and appearance of the full reports, of which these bulletins are but summaries, will be awaited with eagerness.

BALINESE CHARACTER. *A Photographic Analysis. Special Publications of the New York Academy of Sciences, Volume II.*

By Gregory Bateson and Margaret Mead. New York Academy of Sciences, New York City. $3.75. 12 x 9; xvi + 277; 1942.

The beautiful, small island of Bali, off the east coast of Java, is inhabited by one million people. These Balinese possess an Indonesian culture that has been considerably influenced by Buddhist and Hindu sources, while Chinese and Mohammedan contacts have played a minor role. Balinese diet consists chiefly of rice and sweet potatoes, fish and meat being consumed only in small quantities. A variety of domesticated animals are kept, the dog, acting as scavenger, being perhaps the most important one. Support of life is no heavy burden in Bali, hence the people enjoy an abundance of leisure, and were content and gay under Dutch rule before the Japanese invasion.

The authors of this monograph have spent two years in Bali, mostly in one mountain village, studying and photographing the daily life of the natives with special emphasis upon many aspects of behavior which would have seemed unimportant to the older generation of anthropologists. This volume is not primarily devoted to Balinese customs, but concerns itself chiefly with the inhabitants as personalities—how they stand, move, sleep, dance, eat, make love, get married, bury their dead, organize their community life, paint, carve, act in their puppet plays, learn, grow to adulthood, and endless other forms of detailed behavior that reveal the basic cultural and emotional life.

The bulk of this volume consists of 759 photographs accompanied by brief explanatory notes. These candid camera pictures were not posed, they are well reproduced, and have been selected and arranged to illustrate the following main topics: Introductory Subjects (Village and Temples, Agriculture, Irrigation, Industrialization, etc.); Spatial Orientation and Levels (Sharing and Social Organization, etc.); Learning; Integration and Disintegration of the Body (e. g., Trance, Hand Postures); Orifices of the Body (e. g., Eating, Suckling, Body Products); Autocosmic Play (e. g., Toys, Cock-fighting); Parents and Children (Stimulation and Frustration, Tantrums, Fear, Sleep, etc.); Siblings; Stages of Child Development; Rites de Passage (e. g., Tooth-filing, Marriage, Funerals, Exhumation, Continuity of Life). With this wealth of pictorial records and their brief psychological analysis and interpretation, the complex Balinese character is described effectively and thoroughly. This scholarly work closes with an "Ethnographic Note on Bali," a brief bibliography, and a glossary and index.

CROSS SECTIONS OF NEW WORLD PREHISTORY. *A Brief Report on the Work of the Institute of Andean Research, 1941–1942. Smithsonian Miscellaneous Collections, Volume 104, No. 2.*

By Wm. Duncan Strong. Smithsonian Institution, Washington, D. C. (Paper). 9¾ x 6¼; 44 + 33 plates; 1943.

In 1937 a group of American scholars organized the Institute of Andean Research to promote and coordinate anthropological explorations and studies in the Andean area and in related regions for the purpose of advancing our knowledge of the origin and development of the native American civilizations. This is a very condensed account of the organization, as well as of the chief results of the archeological program of this young and promising Institute, which has a list of thirteen distinguished research members and many associated experts, aiding in specific projects. During its brief activities in the field, the Institute of Andean Research has already made numerous and significant contributions to New World prehistory. These are briefly mentioned and illustrated with many excellent photographs. In a chapter on "Future Vistas" the author comments as follows on the present and future status of his specialty: "... it is a strange thing that most social scientists and even some archeologists, who certainly should know better, often dolefully lament the fragmentary nature of the human prehistoric record at a time when they have not yet even begun to exploit systematically its available riches. Certainly in Middle and South America the day of scientific archeology is at its very dawn, and one has

reason to suspect that this is probably true of most of the world. The time is coming when the rich ethnological and archeological record of the New World can be compared in full detail and time perspective with similar records from Europe, Egypt, Mesopotamia, India, China, and Siberia. When such comparative data are in hand the generalizations that will emerge may well revolutionize our concepts of culture history and culture process over the millennia."

Appended are an interesting, tentative "Relative Chronological Chart of Middle and South America" and an impressive list of the publications resulting from the 1941–1942 program of the Institute.

BIOCHEMISTRY

THE CHEMISTRY OF PLANT CONSTITUENTS.

By Ole Gisvold and Charles H. Rogers. Burgess Publishing Company, Minneapolis. $4.25 (paper). $10\frac{3}{4}$ x $8\frac{1}{4}$; xiii + 484; 1943.

Extensively revised to keep up with the many advances which have occurred in this broad field since the first edition appeared in 1938, this multilith-printed volume contains a vast amount of material useful to the student or investigator in the fields of chemistry, biology, or pharmacy.

The introduction outlines briefly the organs of the plant-laboratory in which the many constituents are built up and mentions the raw materials necessary for its efficient functioning as a factory. As is wholly fitting, the treatment of the carbohydrates, expanded in the chemistry of the monosaccharides and otherwise revised, is the most extensive of all the chapters, covering in 100 pages the chemistry of the sugars and their derivatives, of the pectins, cellulose, starch, gums, and the other members of this important class of plant constituents.

The chapter on sterols has been revised, with considerable expansion of the portions dealing with the sterol nucleus, and with the chemistry of the saponins, while the treatment of the large and highly important class of the alkaloids has been completely revised in the light of recent work in this complex and significant field.

Less extensive chapters adequately cover vegetable fats, plant and insect waxes, carotinoids, tannins, terpenes, glycosides, and the anthocyanins and anthoxanthins, that on the last of these having been enlarged from the first edition to include additional material on the chemistry of their structure and on the isoflavones.

To keep pace with the rapid advances in other important and active fields, the discussion of the vitamins has been revised and expanded, while the next chapter on enzymes has been extended by a more detailed treatment of coenzymes and biological oxidations and reductions, with new material on the respiratory enzymes. The final chapter on products of fermentation, although brief, presents the chemistry of most of the microbiological processes used industrially.

The extensive index of 17 pages, from Acactechin to Zymosterol, is apparently restricted in reference to the chemical constituents, neglecting most of the numerous source plants, yet for some reason including a few, such as sea-weeds, *Persea gratissima*, and *Pyrus aucuparia*. It also lacks any reference to penicillin, although this vitally important antibiotic therapeutic agent is mentioned in the text.

The 26 tables, many of which effectively assemble and summarize material extended through the text, add materially to the usefulness of the book. The system of placing pertinent references in condensed and abbreviated form at the bottom of each page, although admittedly saving of space, is open to criticism here because it deprives the student of the background and perspective on a chapter or phase of a subject that assembled lists of references afford. Incidentally, in the 2-page list of abbreviations used in the bibliography, plant pathologists will be astonished to find their official journal designated as "Felix Phytopath," a euphonious and personified "abbreviation" somewhat mystifying to the reader until the source of the error is traced to carelessness in transcribing a reference on page 2.

VEGETABLE FATS AND OILS: *Their Chemistry, Production, and Utilization for Edible, Medicinal and Technical Purposes. Second Edition.*

By George S. Jamieson. Reinhold Publishing Company, New York. $6.75. 9 x 6; 508; 1943.

Fats and oils not only are an essential part of the diet of men and animals, but also play an important role in many industries. Consequently, the life and progress of a nation depend in no small measure on its supply of these products. The demand for fats and oils increases with the growth of population, and through the discovery of new uses for these substances. An attempt has here been made to bring within the compass of one comparatively small volume as much information as possible in regard to the vegetable fats and oils. Those readers requiring other or more detailed information will find the available references under each subject treated. The fats and oils here presented have been divided into three classes: the non-drying, with iodine numbers up to 100; the semi-drying, with iodine numbers from 100 to 130; and the drying, with an iodine number of 130 or more. Whenever feasible, the fats or oils from plants of the same family are grouped together. Although the methods in common use for the extraction of fats and oils are discussed in the first chapter,

further attention is paid to methods of expression under the heading of individual products, such as cottonseed, linseed, and olive oils. Under cottonseed oil, caustic soda refining, bleaching, deodorization, hydrogenation, and the preparation and distillation of fatty acids recovered from refinery soap stock are discussed. These methods are applicable as such, or with slight modification, to the treatment of a large number of other fats and oils. There is a separate chapter devoted to methods, in which several standard procedures are given for each determination or test, including those for the determination of the diene and the thiocyanogen values.

The appendix contains data on the seeds and oils found in a number of ornamental (besides some other) trees and plants, and a series of tables containing pertinent information. For convenience, there are both an alphabetically arranged table of the plant families under which the species are listed, and a botanical index which contains in alphabetical order the species mentioned in this book. There is also a complete subject index. This book should enjoy a wide reading by chemists, technologists, nutritionists, and others concerned with the material it contains.

METABOLISM OF FAT.

By Ida Smedley-Maclean. Methuen and Company, London. 4s. 6⅝ x 4⅛; vi + 104; 1943.

In spite of its brevity, this survey of the biochemistry of the lipids serves to indicate the progress that has been made in our knowledge of the constitution, synthesis, and functions of the fats and related substances. In those sections that probably represent the author's major fields of interest (synthesis, composition, and oxidation), the discussion is especially lucid and critical; and the reader is given a perspective of the accomplishments and the still unsolved problems.

The remaining parts are rather perfunctory in treatment, but as the preface states: "Within the limits of the present volume, it would be impossible to give any complete survey of the field." The reader searching for a more intensive treatment of the entire field will have to refer to Bloor's recent monograph.

LABORATORY MANUAL OF BIOCHEMISTRY. *Second Edition, Revised.*

By Benjamin Harrow, Gilbert C. H. Stone, Harry Wagreich, Ernest Borek and Abraham Mazur. W. B. Saunders Company, Philadelphia and London. $1.50 (paper). 9 x 5⅞; v + 132; 1944.

A laboratory manual is a peculiar entity intended to aid a student toward a more complete mastery of the subject matter of some field of science. Implicitly, it is associated with the methods and aims of teaching; and since these methods and aims in biochemistry are unstandardized, the laboratory manual in this field represents a more or less individualized product, the merit of which cannot be fairly judged.

The laboratory manual by Dr. Harrow and collaborators follows the traditional path of touching on the carbohydrates, lipids, and proteins, on certain enzymes, on saliva, milk, bile, blood, and urine. There are sections on colorimetry and on chromatographic analysis. The directions are given in some detail, with emphasis upon the quantitative aspects. The book is clearly and neatly printed.

THE CHEMISTRY OF SYNTHETIC SUBSTANCES.

By Emil Dreher. Philosophical Library, New York. $3.00. 8¼ x 5¾; 103; 1943.

The chemistry of macromolecular organic compounds, rapidly developed in science and industry, has up to now been considered in existing literature chiefly in the realm of technical application, especially in so far as it concerns the treatment of high molecular weight substances. The present volume, highly technical and limited in its appeal almost solely to chemists and engineers, is designed to give information regarding the underlying theoretical questions involved in the synthesis of those diverse macromolecular compounds of which the synthetic substances being manufactured today consist. The author feels that absorption in such fundamental questions of organic chemistry is indispensable for those interested in the production and manufacture of synthetic substances. This little book really presents a survey, authentic and concise, of the principal questions of macromolecular chemistry. The subject-matter discussed includes: high molecular weight organic compounds; a survey of the relations of synthetic high molecular weight compounds to drying oils; principles of the processes of polymerization; various types of polymerization products; the influence of the constitution and of substituents on the capacity for polymerization of low molecular weight compounds; principles of the processes of polycondensation; and some information on the cognizance of solubility of high molecular weight film-forming substances. A selected bibliography is given at the end of most of the individual chapters. There is no index, which is an unfortunate omission.

SULFONAMIDES. *Annals of the New York Academy of Sciences. Volume 44, Article 5.*

By Colin M. MacLeod, Paul H. Bell, Henry Irving Kohn, J. S. Lockwood, Richard O. Roblin, Jr., James A. Shannon, and H. B. vanDyke. New York Academy of Sciences, New York. Paper; 9¼ x 6½; 445–538 + 4 plates; 1943.

The sulfonamide drugs have so revolutionized the field of chemotherapy in the past few years that it is not surprising to learn of the tremendous scientific effort being put forth in an attempt to learn more of their exact chemical nature, their structural and functional relationships to each other, and their effects on the physiology of bacteria as well as the physiology of the host organism.

In this series of five papers, the most recent pertinent scientific facts concerning the chemistry, pharmacology, and therapy of the sulfonamides have been discussed in an authoritative manner from the standpoint of current, as well as past, experimental evidence.

The first paper deals exclusively with the apparent relationship between the molecular structure of the sulfonamides and their anti-bacterial activity. Although the authors have not included a detailed discussion of this relationship in the present abstract, they have introduced a considerable amount of experimental and mathematical data in support of their basic theory, which is stated as follows: "the more negative the SO_2 group of an N^1-substituted sulfanilamide derivative, the more bacteriostatic the compound will be." The knowledge of the relative positive or negative character of the N^1-substituent provides a wide margin of accuracy in predicting the chemotherapeutic activity of any new sulfanilamide derivative.

The second paper describes several experimental studies on the physiological disposition (distribution, excretion, resorption) of a number of selected sulfanilamides. Most of the experimentation was carried out on the cat, but sufficient observations were made on the dog to indicate that the fundamental principles are probably more generally applicable. In general, it has been shown that the facility with which the sulfanilamides pass through the cell membrane is largely determined by the amount of disassociation they exhibit in the hydrogen-ion concentration encountered in the blood. The authors make no claim for their work as the final word in the relationship between the chemical structure of the sulfonamides and their physiological disposition, but rather point out the value of their method of experimentation in obtaining more exact information on the subject.

The third study is concerned with the toxic effects of the sulfonamides. In excessive dosages and over long periods of time, these compounds have been shown to have definitely deleterious effects on the morphology and chemistry of the blood, on the physiology of the kidney, and on the nervous and cutaneous tissues of the body. The author of this study indicates the importance of further investigations to determine the pathological effects of toxic dosages of the sulfonamides on the liver, spleen, kidneys, and lungs. A list of extremely useful therapeutic cautions is included for the practising physician.

The fourth report covers the antagonists, dynamists, and synergists of the sulfonamides. The role of various bacteria, yeasts, enzymes, and chemical compounds in either stimulating or depressing the effectiveness of certain concentrations of the sulfonamides in the body is outlined. A knowledge of these factors is essential in the application of sulfa-therapy, since it not only points out methods of increasing the potency of the sulfonilamide drugs, but indicates the reasons for their ineffectiveness under certain conditions as well.

The final paper deals with the general action of the sulfonamides in the body, and discusses the urgent need for further investigation into the activity of bacteria in the body fluids in relation to actual or potential immunity. The author here points to the need for further studies in the development of specific drugs which will individually attack such bacteria as cause tuberculosis or endocarditis.

These papers will provide much interesting enlightenment for the entire medical profession, and will unquestionably be eagerly received by the general practitioner as well as the medical teacher or investigator.

BIOMETRY

STATISTICAL ADJUSTMENT OF DATA.

By W. Edwards Deming. John Wiley and Sons; New York; Chapman and Hall, London. $3.50. 8 x 5⅝; x + 261; 1943.

The adjustment of data presented in this book is by the method of least squares, and the book could appropriately be called "Least Squares Adjustment of Data," since no other method is developed. The basic principle of least squares is presented in a different way from the classical approach. It follows in generalized form the line of thought that is inherent in the least squares adjustment of measurements on the angles of a plane triangle to the condition that the sum of the three angles shall equal 180°. As applied to curve fitting, the equation to be fitted becomes a conditional equation to which the adjusted values of the observations are to be subject. This approach unifies the various problems in least squares adjustment and a single general solution is given, to which the solutions of all the special problems are oriented.

The author states at the outset that he is not attempting to cover all statistical methods, nor even the entire field of least squares, but is attempting to supplement other books, with emphasis on scattered portions of the subject of adjustment of data that are difficult to find elsewhere.

Perhaps it is because of this effort to collect scattered matter that the book is very uneven and it is not clear to what type of audience the author addresses himself. In fact, one gets the impression that he has put together papers prepared for different groups

His use of such terms as "standard error" and "Student test" without definition, implies some familiarity on the part of his readers with statistical terminology, yet in Chapter VII he defines at some length the terms "cell" and "cell frequency" in a correlation table, which implies no knowledge of the most elementary terms. Incidentally, he had used these terms previously without definition.

Another difficulty with the style is the continual reference to a later part of the book for the definition or interpretation of the matter under discussion at the moment. Thus such a fundamental concept as the weight of an observation is used in equations and text, in the solution of a problem of equal weights and one of unequal weights before a section is reached entitled "A digression to define weights." The term residual is used in three pages of discussion before it is defined. We find in Section 8 (p. 15) the sentence: "Least squares may also be considered the minimizing of the estimate σ (ext), to be introduced in Section 13." Such frequent reference to future sections for definitions must oblige the person who is not already familiar with the subject matter to jump back and forth in his reading or else to read without understanding.

More serious from the point of view of acquiring a real understanding of the method of least squares and applying it soundly is the failure to stress the assumptions underlying the method. The inquiring student might ask why least squares is preferable to least 4th powers or least absolute deviations, and what criteria must be fulfilled to justify adjustment by this method. What discussion there is of these issues is so scattered and disorderly that it would be virtually impossible for a student to get a view of the complete set of assumptions involved in the process of least squares. The author stresses that he is interested in the practical side of adjustment, that is, in results that can be used as a basis for action." However, in the section on curve fitting he gives the student no guidance whatever on how to select the function to be fitted. Yet every person experienced in curve fitting knows that this is by far the most difficult and critical issue of the entire procedure. The book is weak, therefore, at the very point where most guidance is needed in getting results that furnish a sound basis for action.

THE FOREIGN-BORN POPULATION OF CONNECTICUT, 1940. *Storrs Agricultural Experiment Station Bulletin 246.*

By Nathan L. Whetten and Henry W. Reicken, Jr. University of Connecticut, Storrs. (Paper). 9 x 6; 75 + 27 maps; 1943.

The basic data of this report are from published and unpublished tabulations obtained from the 1940 census. The Appendix, which comprises about half of the Bulletin, contains these raw data. The other half of the report discusses the results of analyzing the material and presents the salient findings in maps and charts.

The foreign-born white population of Connecticut in 1940 was 19 per cent of the population of the state, a proportion exceeded only by New York, Massachusetts, and Rhode Island. Italians and Poles account for a third of this group. The intrastate geographical distribution of each of the ten leading nationalities is presented, together with comparisons of their urban-rural distribution. The Bulletin should be useful to the various groups of workers in education, social service, and racial relations who need to have a view of the distribution, as to origins and basic cultures, of the populations with which they are working.

THE BULLETIN OF MATHEMATICAL BIOPHYSICS. *Volume 6, Number 3, September, 1944.*

Edited by N. Rashevsky. University of Chicago Press, Chicago.

This number contains the following papers: A Theory of Membrane Permeability, by Ingram Bloch; Outline of A Mathematical Theory of the Removal of Malarial Parasites from the Blood Stream, by H. D. Landahl; Simplified Equations for the Distribution of Chloride in Body Water, by Walter S. Wilde; On the Form and Strength of Trees: Part I. The Trunk, by I. Opatowski; A Contribution to the Mathematical Biophysics of Visual Perception and Aesthetics, by N. Rashevsky and Virginia Brown; On the Theory of Blood-Tissue Exchanges: I. Fundamental Equations, by R. E. Smith and M. F. Morales.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

OUT OF THE TEST TUBE. *Fourth Edition, Revised and Expanded.*

By Harry N. Holmes. Emerson Books, Inc., New York. $3.00. 9 x 6; x + 311; 1943.

The fourth edition of this popularized account of chemistry has been extensively revised and emended. Much new material has been added, including chapters on "Strategic Raw Materials" and "Chemistry after the War." It is still one of the most outstanding contributions of its type. Dr. Holmes has done an excellent job in confining the history and development and the modern application of chemical knowledge to civilization in one volume, and in doing it in a very entertaining and readable manner. However, his enthusiasm causes him to stress chemistry to such a degree that he practically denies the existence of other sciences.

THE CONTRIBUTION OF HOLLAND TO THE SCIENCES. *A Symposium.*

Edited by A. J. Barnouw and B. Landheer. With an Introduction by P. Debye. Querido, New York. $3.50. 8 x 5¼; xvii + 373; 1943.

The title of this symposium by Dutch scholars is misleading, for the term "science" is here used so as to embrace most of the fields of knowledge. Of the 352 pages of text, 261 (or nearly 75 per cent) are devoted to the "Humanities and Social Sciences" (theology, philosophy, philology, psychology, sociology, historiography, law, political economy, international law, history of art, musicology, oriental studies, library science, and archival science). The "Exact Sciences and Architecture" (astronomy, mathematics, physics, chemistry, medicine, plant biology, architecture) are covered in the remaining 91 pages. The gaps in the above list are all too evident. Thus there are no sections devoted to general biology, zoology, paleontology, geology, or anthropology. But this, as the editors point out in their preface, was caused by a lack of competent authors for certain subjects.

Although the book is necessarily compressed in style, because of its encyclopedic nature it serves the purpose for which it is intended—to acquaint the reader with Holland's more than considerable contribution to human knowledge. The attainments of living scholars and scientists, for obvious reasons, are not included. But here one may read of the achievements of such men as Erasmus, "the prince of the humanists"; Spinoza, the great rationalist; Lambert ten Kate, student of the Gothic language; Grotius the father of international law; Huygens, mathematician, physicist, and astronomer; and Van't Hoff chemist and physicist—to mention but a few. Of special interest to biologists are the accounts of figures like Leeuwenhoek, Boerhaave, De Vries, Einthoven and Eijkman.

Holland needs no propagandists. Her history speaks for itself. The sober facts, such as those compressed between the covers of this little book, are ample testimony of the tremendous contribution to civilization that has been made by one of the small nations—numerically speaking—of the world.